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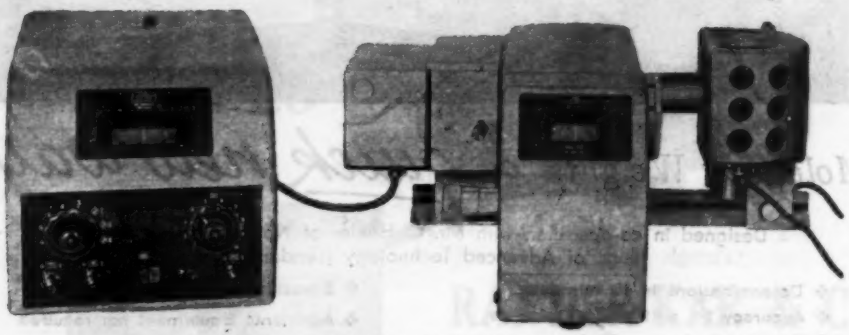

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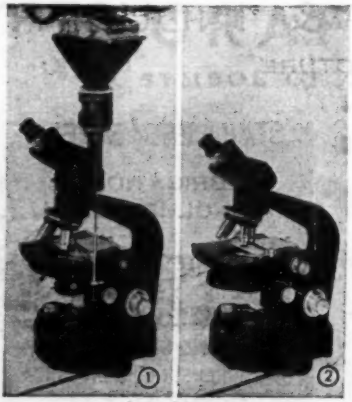

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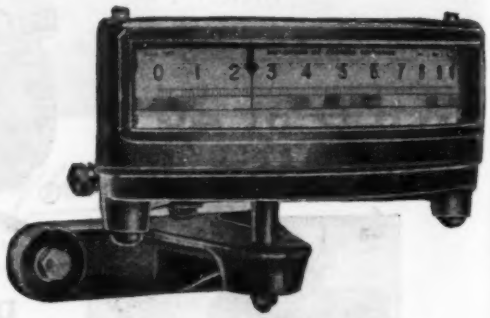

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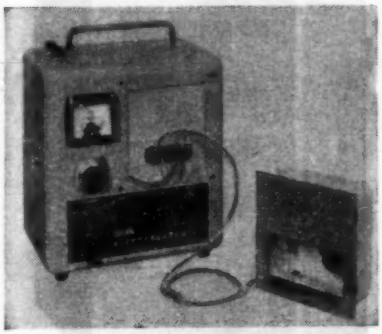

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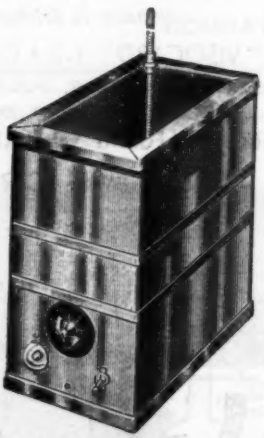

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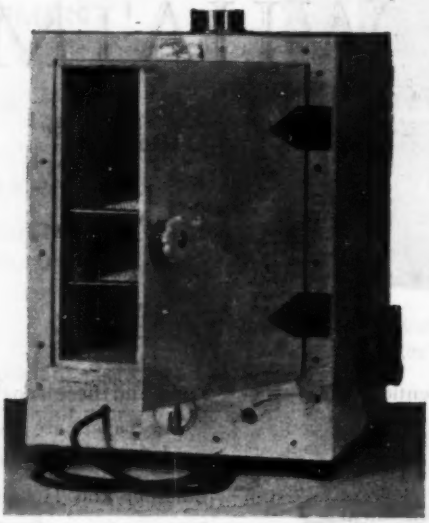

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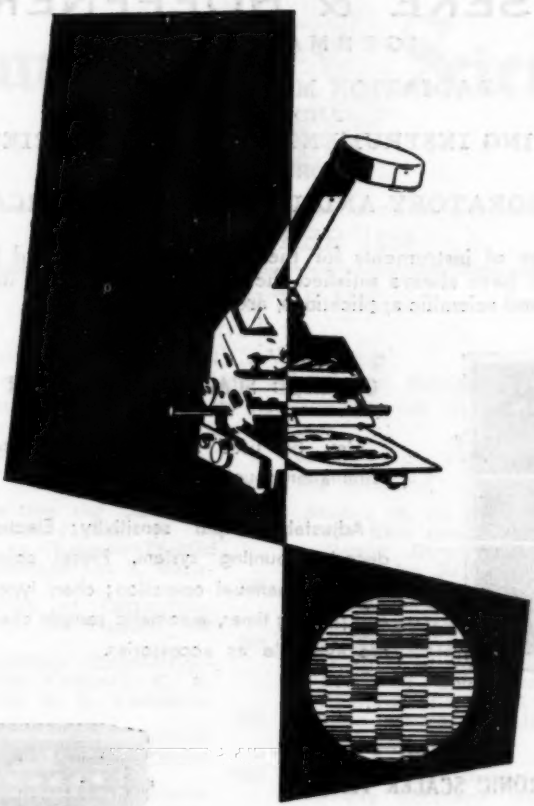

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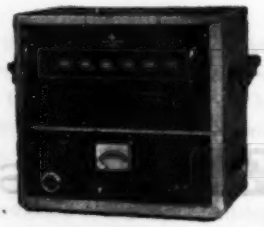

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SCIENCE IN EASTERN EUROPE: I

SIR C. V. RAMAN

LADY RAMAN and myself left for Europe by the s.s. "ASIA" which sailed from Bombay on the 9th of May this year and docked at Genoa in Italy on the morning of the 23rd of the same month. We were in Europe for nine weeks and took the same steamer back to India, leaving Genoa on the 30th of July and reaching Bombay early morning on the 13th of August. We travelled by rail, stopping off at various places for a shorter or longer period as we thought fit. The tour gave us a wonderful opportunity of seeing the countries through which we passed and of obtaining some knowledge of their condition and activities at the present time. This article records some of my personal impressions and it is hoped that it may be of interest to readers of *Current Science*.

The countries we had arranged to visit were in Eastern Europe, but our journey to them took us through Italy and Austria. Proceeding from Genoa to Milan, a brief stop was made at the latter city where we visited the Science Museum recently set up by the civic authorities, in which a remarkable exposition of the pioneer investigations of Leonardo Da Vinci is a noteworthy feature. Travelling from Milan through Verona and the Brenner pass, we reached Innsbruck in Austria where we made an overnight stop. We found Innsbruck to be a town of great charm set in Alpine surroundings of impressive grandeur, and we were thereby confirmed in our resolution to return to it for a longer stop during our return journey. The railway took us across Austria from Innsbruck to Linz *via* Salzburg, through a region of mountains, lakes and valleys of entrancing beauty. At Linz we made an overnight stop, and left next morning for Prague which we reached on the afternoon of the 27th of May.

2. PRAGUE

A feature that impressed us during the journey through Czechoslovakia was the meticulous attention given to agriculture, not an acre of land, so far as we could see, escaping the attention of the cultivator. It was also obvious that we were passing through a highly industrialised country. It did not therefore surprise us to discover when we arrived at Prague that Czechoslovakia pays much attention to advanced studies in science and technology and that research is assiduously pursued.

The Czechoslovakian Academy of Sciences played the host to us at Prague. The Academy had placed a young spectroscopist—Dr. Josef Pliva—on special duty to take me around and he carried out the assignment with energy and enthusiasm. Indeed, the five days of our stay at Prague were crowded with activity. Formal receptions, social engagements, visits to the Research Institutes of the Academy and to the Laboratories of the Technical University and excursions to places of interest around Prague filled up most of the time. I also delivered two lectures at the Physical Institute of the Charles University, the first on "The Specific Heats of Crystals", and the second on "The Physics of the Diamond".

It is not possible here to summarise all that I saw of the scientific life of Czechoslovakia or even to mention the many distinguished men of science with whom I conversed and discussed scientific problems during my stay at Prague. The barest reference to a few items must suffice. I was highly impressed by my visit to the unpretentious laboratory of Professor Jaroslav Heyrovsky, famous as the founder of the polarographic method in physical chemistry. He received me most cordially and expound-

ed for my benefit the basic principles of the subject.

At the Institute of Technical Physics of the Academy, I saw much of interest, a notable item being the preparation of a rod of pure silicon which was in progress. During my visit to the Technical University, I was much struck by the excellence of the mineralogical museum which I saw on one of its floors. The museum was a wonderful collection of beautiful specimens from all parts of the world arranged and exhibited in a remarkably perfect fashion. Finally, I should mention my visit to the Institute for Research in Minerals situated in Tournov about seventy kilometres from Prague. The journey was made by motor through a beautiful landscape known locally as the Czech Paradise. I found that an important section of the Institute was devoted to the synthetic production on a large scale of crystals required for the electrical and other industries. There was also a section devoted to the cutting of quartz and the fabrication of optical instruments made from quartz. A demonstration was given to me of the performance of the so-called birefringent filter made of quartz plates which finds application in astronomy.

3. Moscow and Leningrad

We were at Moscow from the 4th to the 7th of June, and again from the 11th to the 14th of the month, the interval of three days from the 8th to the 10th being taken up by a brief visit to Leningrad. The time thus devoted to these two great centres of scientific activity was, of course, much too short to enable them to be adequately explored. Even what I saw was sufficient, however, to impress upon me the vast scale on which scientific advance is encouraged and supported by the U.S.S.R.

The Institute for Physical Problems directed by Academician Peter Kapitza was the very first to be visited by me. That Institute specializes in the production of low temperatures and the study of the physical

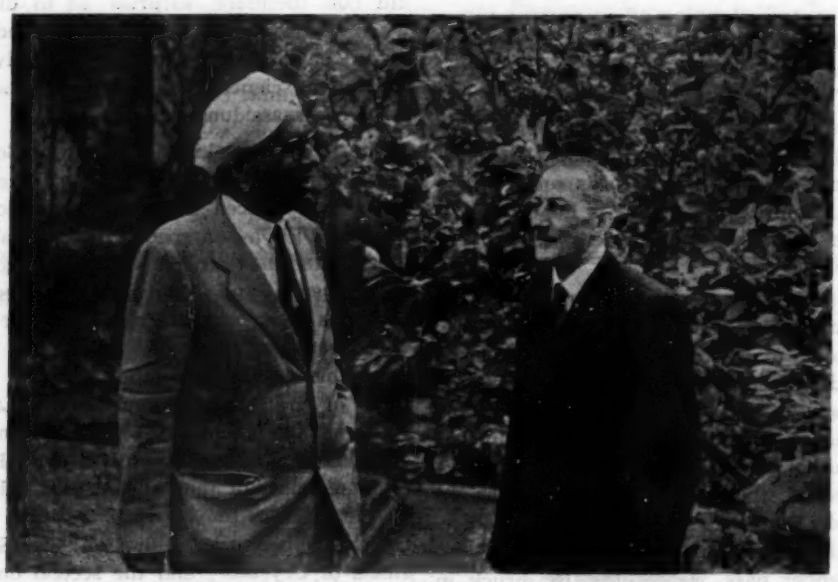

FIG. 1. Professor Heyrovsky in the garden of the Polarographic Institute.

properties of matter at such temperatures. I utilized the facilities available in it for making some preliminary studies on the luminescence spectrum of diamond held at liquid helium temperature. A highly interesting forenoon was spent at the Institute of Crystallography where I was welcomed with special enthusiasm by Academician Belov and his collaborators. A striking exhibit had been there arranged for my benefit of moving films exhibiting the growth of crystals as well as the order-disorder phenomena observed in them. During my return visit to Moscow, I delivered a lecture at the Institute of Prof. Kapitza on "The Thermal Energy of Crystals". On the 12th of June, I was officially received by President Nesmeyanov and his staff at the administrative offices of the U.S.S.R. Academy of Sciences. The next evening, at his invitation, I delivered in the conference room of the Academy a lecture on "The Dextro and Lævo Forms of the Carbon Atom", standing beside a gigantic portrait in oils of the great Russian chemist, Mendeljeff. The Lebedev Institute of Physics directed by Professor Skobeltcyn and the grandiose building of the University of Moscow and its Institute of Physics were also visited.

One day of my brief visit to Leningrad was utilized for a call at the Institute of Semi-conductors directed by the celebrated Russian physicist, Academician Joffe. I was there shown the thermoelectric batteries and the thermoelectric refrigerators which had been developed in the Institute as practical applications of thermoelectricity. On another day, the well-known observatory at Pulkovo near Leningrad directed by Academician Mikhailov was visited. The observatory which had almost been completely destroyed during the war had been reconstructed and is functioning once again. During my tour of the observatory buildings, I was shown a new type of coronograph which had been developed at the observatory. It was evident from what I saw at Pulkovo and elsewhere that great advances in optical technology had been made in the U.S.S.R. and that in the production of optical instruments such as spectrographs, gratings, large mirrors and lenses, the U.S.S.R. is now completely self-sufficient.

4. Kiev

We were at Kiev from the 15th to the 18th of June. This city, the capital of the Ukraine, is beautifully situated on an elevation overlooking the river Dneiper. It has been almost completely reconstructed after the war and but little evidence remains of the destruction caused by the latter. Civic pride is manifest in the tidiness of the roads and the beautifully kept boulevards and gardens.

Though our visit to Kiev was very brief, it was full of interest. The Ukraine has its own Academy of Sciences. At some little distance from the city a new Institute of Physics has been built and equipped which is devoted for the most part to nuclear studies. I was very warmly received by its Director, Academician Pasechnik and his colleagues and went round the laboratories. In the auditorium of the Institute which was filled to capacity, I gave a lecture on the theory of the atomic vibrations in crystals. On the afternoon of the same day, I delivered a semi-popular address in the hall of the University of Kiev describing the results of the Bangalore investigations on iridescent minerals. The various departments of the University were visited later the same evening. The next morning, I went round the Institute of Metals conducted by the Academy and was greatly impressed by the wide range of the problems being investigated by its staff. Here, again, I gave a lecture on "The Diffraction of X-Rays by Diamond". In the afternoon, I visited the Institute of Physical Chemistry of the Ukrainian Academy of Sciences and had a long conference with Academician Brodsky and his colleagues in which problems of common interest to us were discussed.

5. Budapest

Many years ago, before the war, I had been at Budapest for a fortnight. Seeing it again, it was evident that the scars left by war had not all been effaced. Nevertheless, Budapest was beautiful as ever, standing as it does astride the Danube and with the hills overlooking it. We were very happy to be able to devote ten days for our visit to Hungary. The Magyars—as they call themselves—are a gifted people fully capable of rising to great heights of achievement in all the realms of knowledge.

Fig. 2. Tihany and Lake Balaton.

The Hungarian Academy of Sciences played the host to us and we had a wonderfully interesting time. A young spectroscopist, Dr. Laszlo Szalay, Lecturer in Physics in the University of Szeged, was on special duty to look after us and make all the necessary arrangements. Dr. Szalay had prepared for my perusal a highly informative account giving us a complete picture of the state of physics in Hungary and a brief outline of the activities currently in progress under the auspices of the Academy and at the different universities in Hungary. An outstanding recent development has been the establishment of a Central Physical Research Institute—with ten departments—under the auspices of the Academy with Prof. L. Janossy as Director. Prof. Janossy was away in China on a lecturing tour when I arrived at Budapest. Fortunately, however, he returned in time to be able to take an active part in a meeting of the Hungarian Physical Society held on the 27th June. One of the items on the programme of this meeting was a lecture by me on "Physical Research in India". I spoke in English and Prof. Janossy gave a fluent running translation of my speech into Hungarian. Besides this lecture, I gave a systematic course of three lectures on "The Physics of Crystals" under the auspices of the Hungarian Physical Society. These lectures were attended by a large and distinguished audience and every

lecture was followed by a vigorous discussion. The rest of my time was fruitfully spent in visits to the Central Physical Research Institute referred to above and to the various other laboratories in Budapest including especially that directed by Prof. Z. Gyulai—the doyen of Hungarian physicists—which concerned itself with crystal physics and the Research Laboratory of the Tungsten Lamp Industry directed by Dr. G. Szigeti. I witnessed fascinating demonstrations of the work in progress in both of these Institutes.

Limitations of space prevent my giving a fuller account of the scientific activities in Hungary which I witnessed and referring to the other distinguished men of science whom I was privileged to meet and discuss scientific problems with. This account of my sojourn in Hungary would however be incomplete if I do not at least mention the Lake of Balaton and Tihany where we stayed on Sunday, the 21st of June—a lovely beauty spot as can be seen from the picture reproduced. The day before we left for Rumania, Dr. Szalay took us on a motor ride across Hungary to visit his own University of Szeged. The physicists of the University were mostly away attending the meetings at Budapest. But we had the pleasure of visiting Dr. Szalay's own home and of a short conference with the theoretical physicist, Dr. János Horváth on subjects of common interest to us.

(To be continued)

GOLDEN JUBILEE OF THE INDIAN INSTITUTE OF SCIENCE, BANGALORE

THE Indian Institute of Science at Bangalore owes its origin to the munificence of the late Mr. J. N. Tata and his sons. The establishment of the Institute in 1909 was a notable event in the history of the development of facilities for advanced scientific studies and research in the country. The Government of Mysore and the Government of India have throughout been identified with the growth and development of the Institute. Its activities began with the Departments of Chemistry and of Electrical Technology. Sir C. V. Raman, the first Indian Director of the Institute, started the Department of Physics in 1933. His connection with the Institute for 15 years, till 1948, will long be remembered.

Since independence, with the Prime Minister's well-known enthusiasm for scientific advancement, and with the realisation of the important role of science in the country's industrial and engineering developments, the Union Government have been taking a keen interest and the increased grants given by it have led to a rapid expansion of the activities of the Institute. There are now 17 departments, each having its well-equipped laboratories and a highly qualified staff. There are 150 members on the staff and the number of students is about 400. Under the various programmes sponsored by the Ministry of Education, such as Technical Co-operation Mission, Colombo Plan, etc., the Institute gets the advantage of visiting professors and research workers from abroad. In addition to research and advanced training in all the departments, many of them have post-graduate teaching courses leading to degrees like B.Sc. in Aeronautical Engineering, B.Sc. in Metallurgy, B.E. and M.E. The Institute confers also research degrees, *viz.*, M.Sc., Ph.D. and D.Sc.

Since the Institute was established in 1909, it is proposed to hold the Golden Jubilee of the Institute in February 1959. The whole of 1959 will be the Golden Jubilee Year of the Institute. The President of India, who is the Visitor of the Institute, has graciously consented to inaugurate the Golden Jubilee Celebrations early in February 1959. Throughout the year there will be a number of symposia on various topics of scientific and engineering interest. It is proposed to bring forth a number of publications and to organise an Exhibition during the year. We look forward to an era of vigorous development of the Institute under the leadership of its present Director who has a rich background of experience, alike in the fields of scientific research and of educational administration.

INFORMATION THEORY AND SOME OF ITS APPLICATIONS

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Introduction

IT is difficult to trace the precise origins of many scientific theories. With information theory, sometimes called communication theory, one need not go back farther than the twenties when Nyquist and Hartley tried to develop a quantitative measure of information to assess the capacities of telecommunication systems. It is only during the last decade or so, however, that a theory of information has been developed and its concepts have found widespread use outside telecommunication engineering. Norbert Wiener, to whom the basic philosophy of modern information theory is due, was the first to recognize the universal character of the communication problem encountered not only in telecommunication systems but also in living beings and social organizations. We read in his book on Cybernetics a panoramic description of the growth of these ideas against the background of the problems of the last war. A little later, in 1948, Claude E. Shannon of the Bell Telephone Laboratories published his classic papers on the mathematical theory of communication. Although Shannon was concerned in his work primarily with the telecommunication porblem, the mathematical model he set up for a communication system has been found to be useful in many different disciplines and the concepts of communication theory have penetrated into fields as far away as linguistics, psychology, neurophysiology and others. Today, ten years later, the domain of information theory extends far beyond telecommunication engineering and some of its most interesting problems lie just on the boundaries of telecommunication and other sciences. Nevertheless, in an expository account it is desirable to develop the fundamental concepts of information theory within the confines of telecommunication engineering before their use in other fields is considered. We shall lean heavily on Shannon's work in introducing the current notions of communication theory.

Anatomy of Telecommunication Systems

In the interests of a general theory of communication we must abstract from the wide variety of communication systems the essential features which they all have in common. Every communication system is primarily a device for transmitting messages from their sources to their destinations. These messages may be spoken words with an acoustic pressure-time pattern as in telephone conversation, written characters as in telegraphy or the colour and intensity patterns of light from an object being televised or any other set of symbolic patterns. They may even be numerical data relating to some physical quantity such as temperature or density under observation. A very successful model of a general communication system, due to Shannon, may be represented schematically by the block diagram of Fig. 1.

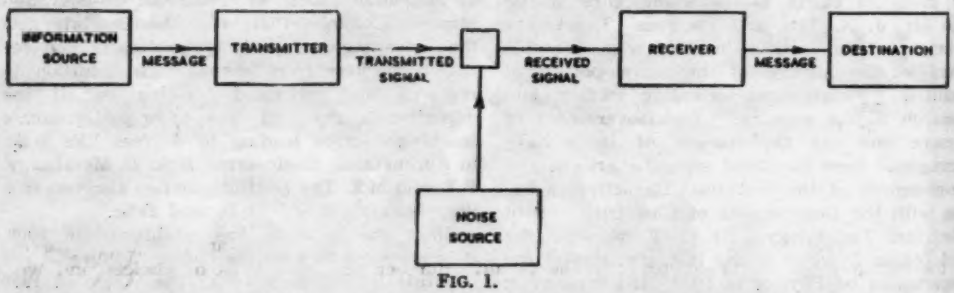

FIG. 1.

Operationally, we may characterise the different elements in this system as follows:

Ignoring all questions concerning the motivation of the messages, we may regard the function of the information source is to generate sequences of symbols or patterns which constitute the messages. We shall first deal with discrete sources which use only a discrete set of symbols like the letters of the alphabet and then take up continuous sources which produce continuously variable patterns like those of the speech-waves. The messages ordinarily used in practice convey a meaning because of the fact that the symbols used, i.e., the written words, spoken sounds, etc., are associated with certain concepts, but we must here make a distinction between the *significant*, the symbol and the

signifie, the entity which is symbolized. In the development of the telecommunication theory, the semantic aspects of the messages were set aside as the engineering of communication systems does not depend upon the meaning of the messages and much less upon their motivation. We should thus look upon messages which communication systems handle as an ensemble of sequences of symbols. It is the statistical rather than the semantical aspects of the messages that concern us. We are thus led to regard an information source as a stochastic or a Markoff process generating its messages symbol after symbol.

In electrical communication the original message symbols are frequently converted into a different set of symbols more suitable for transmission over the communication medium or channel. In telegraphy the letters of the message are converted into the sequence of dots and dashes for signalling according to the Morse code; in telephony the acoustic wave is converted into the corresponding electrical signal. In the above representation the transmitter which may involve a human operator thus performs the operation of producing the sequence of signal symbols at its output from the message symbols fed to its input. Functionally, the transmitter is an operator which maps the message space on the signal space.

The intervening medium between the transmitter and the receiver is called the channel. The channel may be susceptible to noise in which case the signal reaching the receiver differs from the transmitted signal. The noise, like the message, may be regarded as the output of a stochastic or a Markoff process. For instance, the noise in a pair of telephone wires may be due to cross-talk from an adjacent pair. It may be simply due to the random thermal motions of the electrons in the circuit elements. In any event, the effect of noise is to alter the signal in an unpredictable manner except in a statistical sense. It will be seen that the ability of a channel to transmit messages depends upon the band of frequencies it can transmit (the bandwidth of the channel) and the level of the signal relative to that of the noise.

The function of the receiver is to reconstruct the original message from the received signal and hence it may be thought of as an inverse operator to the transmitter. If the received signal is badly perturbed by noise, correct reconstruction of the message from the received signal may not be possible and there remains some uncertainty about the original message. The destination is obviously the terminating point for the message and may be a recording device like a photographic film or a magnetic tape or even a human sense organ like the ear or the eye. It comes into consideration here because the resolving power of the terminating device determines the degree of detail that we need transmit.

A Measure of Information

Having described the basic elements of a generalized communication system we proceed to develop the fundamental concept of information. When we ignore the meaning and look at the message as the output of a stochastic process (as a cryptanalyst does when deciphering a cryptogram) we begin to notice that the various symbols of the message (letters, etc.) are not entirely random but exhibit certain statistical regularities such as the constant frequencies of the letters, etc. The statistical properties as defined, for instance, by the probabilities of the occurrence of the different symbols, the transition probabilities between successive symbols, etc., enable us to define a quantitative property of the message called the information content or entropy of the message. We are certainly not using the word information here in an unconventional sense although we intend to attach a numerical measure to the information contained in the message. To be sure, the information content of a message is not the same thing as its meaning; meaning or rather its comprehension has a subjective side while the information is a measurable quantity without reference to the meaning of the message.

To develop a quantitative measure of information consistent with its commonsense usage, notice that we seek information only when we are in doubt, which arises when there are a number of alternatives or choices and we are uncertain of the outcome of the event. We go to an enquiry office (rightly called information office in America) to remove our doubts; we consult weather forecasts for information whether it will be rain or sunshine; we are, in fact, seeking information (in the form of data) when we perform experiments whether they are launching of sputniks or the testing of nuclear weapons. On the other hand, if an event can happen in only one way, there is no choice or uncertainty about it and no information is called for either. Obtaining information is equivalent to making a choice thereby removing the *a priori* doubt. Choice, uncertainty or doubt and information thus all come to possess the same measure.

Any written message in English can thus be regarded as the result of a sequence of different choices from the 26 letters of the English alphabet. It will be convenient to regard the space between words as a symbol by itself and consider the alphabet to have 27 letters instead. We can thus form no more than 27^N different messages of N symbols length. Only a very tiny fraction of these correspond to the conventional use of English and are thus used in preference to the others. What is more, we can associate with each message a certain *a priori* probability if we have sufficient knowledge of the statistics of the message symbols, i.e., their probabilities, etc.

How much information does a given message contain? First, we need a unit to measure information and then the probability measure of the message. The most elementary type of choice we have is the choice between two equally probable alternatives (*e.g.*, the choice between the heads and tails in the tossing of a coin). For reasons which will become more convincing as we proceed, we shall choose the logarithm to the base 2 of the number of alternatives as the amount of information H associated with the choice so that, in the binary choice referred to above, we obtain one unit of information ($H = \log_2 2 = 1$) which is designated as a bit. If there are N equally probable alternatives, we obtain $H = \log_2 N$ bits of information with the specification of any one of them. In this case since the probability of any of the alternatives is $p = 1/N$, the definition is equivalent to choosing the negative logarithm of the probability of the event as the measure of the information associated with the selection.

The various symbols, however, do not occur with equal probability (the letter *e* has the highest frequency of occurrence, about 13% and *z* has the least, about 0·09%). If different symbols have different probabilities p_i ($i = 1, 2, \ldots n$), and occur independently of each other, the average amount of information per symbol (of the event x, say), may be shown to be given by

$$H(x) = -\sum p_i \log_2 p_i \text{ bits.} \qquad (1)$$

The only requirements imposed by Shannon in obtaining this measure are that (i) H should be a continuous function of the p_is, (ii) when all the p_is are equal, *i.e.*, each $p_i = 1/n$, it should be a monotonic increasing function of n, and (iii) that if the choice be made in successive stages, the weighted sum of the individual values of H associated with each stage must be equal to the value of H obtained by direct selection. Notice, however, that the expression (1) can be interpreted as the weighted average of the information obtained with the selection of each symbol, the weight factor being the probability p_i of the symbol. The formal resemblance of this expression for the amount of information to the entropy of a thermodynamical system which can have n different complexions with probabilities p_i cannot escape notice here. For this reason the term entropy is frequently used to refer to the average amount of information associated with a set of alternatives.

We digress for a short while here to examine the stochastic character of actual messages. Shannon and Miller have given striking demonstrations of how we approach actual languages by merely choosing successive letters or words incorporating longer and longer probabiliy constraints in their choice (see references 1 and 8).

A typical 'sentence' of zero-order approximation is obtained by choosing all the letters with equal probability and independently:

XFOML RXKHRJFFJUJ ZLPWCFWKCYJ FFJEYVKCQSGXYD QPAAMKBZAACI-BZLHJQD

The first order approximation is obtained by choosing the letters independently but with frequencies as in English:

OCRO HLI RGWR NMIELWIS EU LL NBNESEBYA TH EEI ALHENHTTPA OOBTTVA NAH BRL

The second order approximation incorporates the transition probabilities between successive letters and hence has the same digram (*i.e.*, letter-pair) frequencies as in English:

ON IE ANTSOUTINYS ARE T INCTORE ST BE S DEAMY ACHIN D ILONASIVE TUCOOWE AT TEASONARE FUSO TIZIN ANDY TOBE SEACE CTISBE

The third order approximation ensures correct trigram structure:

IN NO IST LAT WHEY CRATCIT FROURE BIRS GROCID PONDENOME OF DEMONSTURES OF THE REPTAGIN IS REGOA CTIONA OF CRE

Higher order approximations with letters cannot be constructed due to lack of statistics regarding tetragrams, etc., but Miller, following Shannon, used words instead of letters and constructed approximations up to the seventh order.

Zero Order: BETWIXT TRUMPETER PEBBLY COMPLICATION VIGOROUS TIPPLE CAREEN OBSCURE ATTRACTIVE CONSEQUENCE EXPEDITION PANE UNPUNISHED

First Order: IS TO WENT BIPED THE OF BEFORE LOVE TURTLEDOVES THE SPINS AND I OF YARD THAN ASK WENT GREEK YESTERDAY

Second Order: SUN WAS NICE DORMITORY IS I LIKE CHOCOLATE CAKE BUT I THINK THAT BOOK IS HE WANTS TO SCHOOL THERE

Third Order: FAMILY WAS LARGE DARK ANIMAL CAME ROARING DOWN THE MIDDLE OF MY FRIENDS LOVE BOOKS PASSIONATELY EVERY KISS IS FINE

Fourth Order: WENT TO THE MOVIES WITH A MAN I USED TO GO TOWARDS THE HARVARD SQUARE IN CAMBRIDGE IS MAD FUN FOR

Seventh Order: SAID THAT HE WAS AFRAID OF DOGS MARKED WITH WHITE SPOTS AND WITH BLACK SPOTS COVERING IT THE LEOPARD DID

These were obtained as follows: To obtain the third order approximation, for instance, Miller chose the sequence of the first two words from a text and asked a person to supply the next word to form a sentence so that the transition from the first pair of words to the third takes place as in common English. This word is noted along, the first word is concealed and the last two now given to another person and the next word obtained. The process is repeated using different persons every time a word is obtained. The other approximations are constructed in a similar manner. The resemblance to natural English increases at each stage although the messages are not purposive and motivated and thus strengthens the conviction that natural languages can be represented by sufficiently complex stochastic processes.

The examples above show that the first order approximation which takes only the letter frequencies into account is a rather poor one for real languages. The expression for the entropy can, however, be generalised readily to include constraints between symbols. If the choice of each letter depends upon the preceding one and only on that, we can define the entropy per symbol from digrams of the type ij as

$$H = \tfrac{1}{2} H(xy) = -\tfrac{1}{2} \sum_{i,j} p(i,j) \log_2 p(i,j) \quad (2)$$

where $p(i, j)$ is the probability of the digram ij or as

$$H = H_x(y) = -\sum_i p(i) \sum_j p_i(j) \log_2 p_i(j) \quad (3)$$

where $p_i(j)$ is the transition probability from the ith symbol to the jth and $p(i)$ is the probability of the occurrence of the ith symbol.

The extension to the case where the choice of a symbol depends upon the preceding $n-1$ symbols is now obvious. We obtain the average entropy per symbol by considering the probability of blocks of n symbols or the transition probabilities from blocks of $n-1$ symbols length to the next one. We may also interpret the relation (3) as the average entropy of the second symbol weighted in accordance with the probability of occurrence of the first. As the information obtained is the same as the uncertainty removed, it also measures how uncertain we are, on the average, of the next symbol knowing the previous one. More generally it is called the conditional entropy of the second event y relative to the first event x and is denoted by $H_x(y)$. The expression

$$H(x, y) = -\sum_{i,j} p(i,j) \log_2 p(i,j)$$

may likewise be interpreted as the entropy or uncertainty of the joint event xy.

Some Properties of the Information Measure

We shall now exhibit some properties of the measure of information which support the claim that the entropy of a set of probabilities (as defined above) measures the choice or the uncertainty associated with them in accordance with our intuitive requirements:

(*i*) If there are n possible ways an event can happen with probabilities $p_1, p_2, \ldots p_n$, then the entropy H is a maximum when all the p_is are equal as may be seen by maximizing H. This is obviously the most uncertain situation.

(*ii*) H vanishes when all the p_is are zero except one which is unity. There is no choice, no uncertainty and no information either.

(*iii*) It may be shown from our definitions of $H(x)$, $H(x, y)$, $H_x(y)$, etc., that the relations

$$H(x,y) \leq H(x) + H(y) \quad (4)$$

$$H(x,y) = H(x) + H_x(y) = H(y) + H_y(x) \quad (5)$$

and hence

$$H_x(y) \leq H(y), \quad H_y(x) \leq H(x) \quad (6)$$

hold good.

The first of these states that the amount of information (or the uncertainty) of the joint event xy is equal to or less than the sum of the informations (or the uncertainties) associated with the individual events x and y. The second relation means that the uncertainty of the joint event xy is equal to or less than the uncertainty of the event x *plus* the uncertainty of the event y knowing x and *vice versa*. The last statement asserts that the uncertainty $H_x(y)$ of the event y knowing the event x is equal to or less than the uncertainty of y

without a knowledge of x and *vice versa*. The equality obtains when x and y are independent events.

Redundancy

These considerations regarding the entropy of a message lead us to the important concept of redundancy, a knowledge of which enables us to design suitable codes for transmission of messages. We have seen that the entropy is a maximum when all the symbols are independent and equiprobable. In English language the maximum entropy per smybol would be $\log_2 27 = 4{\cdot}76$ bits (corresponding to the zero-order approximation), but the entropies calculated on the basis of letter, digram and trigram frequencies turn out to be 4·03, 3·31 and 3·10 bits per symbol. There is evidence that if we consider constraints extending over longer sequences, the entropy reduces down to about 1·5 bits per symbol. The ratio of the actual entropy obtained in a given message to the maximum possible entropy is called the relative entropy and one *minus* the relative entropy the redundancy in the message. The farther the possibilities p_is are removed from the equiprobable case, the greater is the redundancy, the extreme case being one in which all the p_is except one are zero. The letter u after q is an example of this extreme case of redundancy. In English one finds a redundancy of 15% on the basis of letter frequencies alone and about 30% on the basis of digram frequencies. Consideration of longer sequences leads to redundancies as much as 70% or more. Just as the entropy measures how uncertain we are on the average about the outcome of an event, the redundancy is an average measure of our confidence in the outcome. A highly redundant source produces less information per symbol than a less redundant source and conversely to convey the same information we need the least number of symbols when the alphabet is used without any redundancy. Redundancy, however, insures the message against misrepresentation. Any letter after q can always be corrected as u. The price we pay for securing the correct transmission is an increase in the length of the message and the resulting slower rate of transmission.

The immediate significance of redundancy to the telecommunication problem lies in the fact that some of the redundancy may be removed in the process of encoding the message into the signal for transmission. A code is a unique correspondence between the message symbols and the signal symbols or between groups of them in a one-to-one fashion. There are, however, severe restrictions set by noise and the inevitable delays in encoding on the extent to which the redundancy in a message can be removed.

Rate of Generation of Information and Channel Capacity

When we realise that the generation of each of the message symbols requires a finite time, we can also define the time rate at which information is produced by the stochastic process. If the durations of the different symbols are t_i then the average rate of generation of information is

$$H' = H/\sum p_i t_i \quad \text{bits/sec.} \qquad (7)$$

i.e., the average entropy per symbol divided by the average duration of the symbols. The rate of transmission of information over the channel is likewise determined by the duration t'_i of the channel symbols constituting the signal. (We are assuming here that the physical properties of the channel permit the transmission of the signal symbols at least as fast as they are produced.) This rate is not necessarily the maximum possible rate at which information can be transmitted over the channel with the given set of channel symbols as these may not be occurring with the optimal frequencies. The channel capacity is defined as the maximum rate at which information can be transmitted over the channel, given the durations of the channel symbols and the constraints that must be obeyed. This capacity rate of transmission is to be achieved by suitably assigning the probabilities of the different symbols and their transitions with due regard to their duration. One of the basic theorems of communication theory tells that there exists a code by which the output of a source producing entropy at the rate of H bits per symbol can be transmitted over a channel of capacity C bits per second at the maximum possible rate of $[(C/H) - \epsilon]$ symbols per second and ϵ can be made arbitrarily small. The emphasis here is on the possibility of a code by which the information produced by the source can be transmitted at the full capacity of the channel. To approach this limiting value, in general, increasingly long delays are needed in coding and decoding as longer and longer sequences have to be examined. One simple example of a perfectly matching code may be given: Let a source produce the four symbols A, B, C, D with probabilities 1/2, 1/4, 1/8 and 1/8 respectively so that the entropy works out at 7/4 bits per symbol

according to (1). A binary (i.e., a two-symbol) code can be construed as follows:

Write the original symbols in order of decreasing probability and divide them first into two groups (here A and B, C, D) of equal (or as nearly equal as possible) probability and assign 0 to the first and 1 to the second group. Proceed to subdivide each group and assign additional binary digits 0 and 1 in the same way to the subdivisions until each symbol is given a unique representation as illustrated below.

Message symbols	Signal Symbols
A	0
1st div.	
B	1 0
2nd div.	
C	1 1 0
3rd div.	
D	1 1 1

It will be seen that a typical long message in A, B, C, D will result in producing the channel symbols 0 and 1 with equal probabilities so that they carry maximum information. We must remember that with such ideal coding which removes all redundancy any error in transmission cannot be corrected.

Noise in Communication Systems

To make our discussion realistic we must include the effect of noise in transmission, which perturbs the transmitted signal in an unpredictable way. Thus if the transmitter produces the symbol i at the input to the channel, there is no certainty that it will be received as i at the receiver; all that we have are conditional probabilities $p_i(j)$ that if the symbol i is transmitted, it will be perturbed into the symbol j at the receiving end. If the noise is not bad, the $p_i(i)$s will be nearly unity and all other $p_i(j)$s will be small, the noiseless case being the special one for which $p_i(j) = \delta_{ij}$. Therefore, when a message is received over a noisy channel there will be some uncertainty of what the transmitted message was.

How much information is conveyed by each symbol under these conditions? Assuming for simplicity that the input symbols are independent and further that noise affects each symbol independently, we can compute the entropy input per symbol $H(x)$ on the basis of the probabilities of the input symbols and likewise, the entropy $H(y)$ of the output symbols. Knowing the $p_i(j)$s, which characterise the noise source, from previous statistics, we can also compute the conditional entropy which measures

$$H_x(y) = -\sum_i p(i) \sum_j p_i(j) \log p_i(j)$$

the average uncertainty of transmission. It is therefore proper to define the actual information transmitted over the channel as the received information $H(y)$ less the uncertainty $H_x(y)$ in its transmission. Thus the average information transmitted per symbol is $H(y) - H_x(y)$ or in view of the relation (5), $H(x) - H_y(x)$. The latter expression may be interpreted as the amount of information sent less the uncertainty that remains of the transmitted message after the message is in hand. To use such a noisy channel to its capacity we must maximize $H(x) - H_y(x)$ by assigning the probabilities $p(i)$ of the input symbols in the optimal way. Roughly speaking, if all the symbols are of the same duration, those symbols which are least disturbed by noise are to be used most frequently.

Continuous Systems

The messages and signals discussed so far use a discrete alphabet. There are, however, messages like those due to speech-waves, etc., which are conventionally regarded as being continuous and also continuously variable. The problem of developing a measure of the information produced by such continuous messages may be approached in two different ways: The messages constitute an ensemble with a probability density measure $p(x)$, where x is some statistic such as the pressure amplitude of the different possible speech-wave forms at some fixed instant. For such continuous distributions Shannon has formulated the entropy as

$$H(x) = -\int_{-\infty}^{\infty} p(x) \log p(x)\, dx. \qquad (8)$$

In the continuous case also the entropy possesses the properties analogous to (i) to (iii) of the discrete distributions. A particularly interesting property of the continuous distribution is that if the standard deviation is fixed at some value σ, the entropy in (8) has the maximum value $\log \sqrt{2\pi e}\,\sigma$, when $p(x)$ is gaussian, i.e.,

$$p(x) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-x^2/2\sigma^2}. \qquad (9)$$

A more practical approach to the entropy (and the channel capacity) in the continuous case is based on the fact that in practice there is a least upper bound W to the frequencies produced by any source of information. There is an important theorem, called the sampling theorem, which states that if a function of time $f(t)$ contains only frequencies between 0 and W cycles per second, then it is completely determined by specifying its values (i.e., the

ordinates) at discrete points 1/2 W seconds apart. Thus we need only state a finite number 2 W of ordinates to specify a function over one second. Moreover, the accuracy of specification need not be greater than the resolving power of the ultimate destination or the level of the ambient noise fluctuation to which the channel may be subject. Thus both the abscissæ and the ordinates of the function can only assume discrete values. This double quantization reduces the continuous case in practice to the discrete case.

Capacity of a Noisy Channel

One of the most important contributions of modern information theory is the determination of the maximum possible rate at which information can be transmitted over a channel perturbed by white thermal noise of power N. Thermal noise of power N is characterized by the fact that its amplitudes are independent and have the gaussian probability distribution (9) with standard deviation $\sigma = \sqrt{N}$. Therefore, the entropy produced by the noise source in one second is $2\,W \log \sqrt{2\pi e N}$. Given a signal of power P, to carry maximum information it must also assume a gaussian distribution with the standard deviation $\sigma = \sqrt{P}$. As the transmitted signal power and the noise power add directly during the course of transmission, the received signal will have the power $P + N$, and will also have a gaussian distribution with $\sigma = \sqrt{P+N}$. The entropy of the received signal [corresponding to $H(y)$ in the discrete case] per second will be $2\,W \log \sqrt{2\pi e(P+N)}$. The channel capacity C is obtained by subtracting from this the uncertainty due to noise. Thus

$$C = W \log \frac{P+N}{N} \text{ bits/sec.} \qquad (10)$$

This is known as the Shannon-Hartley Law. Regarded as an exchange relation between the channel capacity, bandwidth and signal-to-noise ratio, it shows what is possible under ideal conditions.

Information Theory Outside Telecommunication Engineering

The science of telecommunication abuts on many scientific disciplines, in particular, linguistics, psychology, neurophysiology and others not to speak of its obvious connections with certain branches of physics like acoustics and statistical mechanics. It stems out of the fact that in the telecommunication chain, the ultimate source of information and the ultimate destination happen to be nearly always a human being. We are thus confronted with the problem of matching the telecommunication channel to the human channel. The concepts of telecommunication theory provide valuable analogies in the field of human communication and we can ask questions like "How is information transmitted in the human being and what are his capacities as a channel?" We have no satisfactory way of answering these questions yet but these problems are receiving attention in several fields. Models of communication in the human being, beginning with the physical stimulus and ending with the behavioural response, have been put forward following the general framework of the telecommunication systems. Some recent experimental work by Miller, Licklider, Pierce and others indicates that human beings cannot probably take in information at a rate much greater than about 50 bits per second through the sense organs like the ear and the eye. The importance of the problem of matching the telecommunication and the human channels becomes obvious when we observe that our present telecommunication systems utilize channel capacities several orders of magnitudes greater than that of the human channel. In the outline that follows (which necessarily belongs to the controversial) we can only hope to direct attention to some of the problems in this sphere. We must caution, however, that speculative hypotheses and theorizations which appear frequently in literature should not be mistaken to have any accepted standing.

Language and Human Communication

Communication by speech and writing have been going through a process of evolution long before we could extend their scope by telecommunication and form, even today, the bulk of our communicative activity. Speech or (written) language usually appears as the input and output of most telecommunication systems which is but one reason for our interest in these. Even before the development of information theory, a very considerable body of statistical data regarding the characteristics of speech and language has been gathered over a number of years. The growth of telephone systems following the development of the vacuum tube initiated systematic investigations into the physical characteristics of speech. The needs of the military for secret communication by codes and for deciphering enemy cryptograms provided an early incentive for the study of

the relative frequencies of different letter symbols, digrams, trigrams, etc. With information theory came the realization that these statistical data define a measurable property of speech and language. The point of view has also emerged that speech and language may themselves be regarded as codes for certain conceptual entities. The question of what are the principles which underlie this coding process has received some attention recently.

The first concern of information theorists with speech and language has almost always been to determine the extent of redundancy in a given message. The proper exploitation of redundancy offers one of the most hopeful means of more effective utilization of the channel capacities. Hence the search for the information bearing elements (or shortly *ibes*) of speech. The fact that some saving in channel capacity required to transmit intelligible speech may be possible was appreciated for some time. One of the most successful practical attempts in this direction was the Bell Telephone Laboratories' *Vocoder* which indicates that a bandwidth of some 300 cps. may be adequate for intelligible communication as compared with the nearly 3,000 cps. used in telephony. That speech is highly redundant has been amply established by a number of experiments with speech-waves during the last decade. The intelligibility of speech was tested on speech-sounds, syllables, and words using transmission systems which distort it in a variety of ways, *e.g.*, by clipping off the positive and negative peaks till the wave becomes nearly rectangular, by interrupting the wave at a rapid rate, etc. Even when the wave form is severely distorted, speech retains its intelligibility to a remarkable degree, indicating the presence of a great deal of redundancy. This is not surprising as we already saw that the output of a continuous source has maximum entropy when it corresponds to white noise. It is correct, though uncomplimentary, to say that human speech fails to be informative to the extent that it falls short of noise. How much of this redundancy can be removed and how best the remaining can be utilized in a given situation are questions which will continue to engage our attention.

Semantic and Pragmatic Questions

Following Shannon's example, information theory has been developed (as we have done above) without attention to the meaning of the messages. This point of view was adequate as long as one's problems were strictly confined to telecommunication systems, but when once the human terminal is considered, we can no longer ignore the semantic and pragmatic problems involved. Obviously, the use of the concepts of information theory in the semantic and pragmatic fields needs both clarification and caution. As one illustration, consider a message like 'The sun will rise in the east tomorrow'. One feels intuitively that the message is highly redundant because one has no *a priori* doubt about the truth of the statement and yet the statement is not redundant in the same sense that the letter u is redundant after q. The redundancy here is at the semantic level and not at the syntactic level as in the case of u after q. There is evidently a need for a more general theory of information which includes the meaning of the messages. Bar Hillel and Carnap have advanced, however, a theory of semantic information in the limited sense that their theory takes into account the concepts or the entities to which the symbols refer. It does not, however, take into account the meaning of the messages.

The problem of semantic information is not entirely separable from the information of the telecommunication problem, sometimes called the selective information to distinguish it from the semantic information. For, if we have the choice between two languages in which to transmit the same semantic information, we would naturally prefer to transmit it in the language which requires the smaller number of bits of selective information. Following this line of reasoning, in the course of their studies in Indian languages from the information theory point of view, the author and his co-workers have recently advanced the view that it is possible to compare the relative efficiencies of different languages for communication of semantic content without reference to its absolute value. To use a metaphor, translation from one language to another is a transformation of the code which leaves the semantic content, but not the selective entropy of the code symbols, invariant. The total number of bits of selective information contained in semantically equivalent materials in different languages are thus, in a sense, the appropriate measures of the efficiencies with which different languages encode semantic content into linguistic symbols. A preliminary comparative study of English and German languages, considered as alternate codes for communication of semantic content, revealed some interesting aspects of the process of translation. On counting the number of bits of information in samples of texts in English and their translations into German, it was observed that a bit in German is semantically

equivalent to about 0·82 bits in English. On the other hand, when translations from German to English were examined, one bit in German was found to be equivalent to 0·94 bits in English. A unique ratio may, however, be obtained on the assumption that translation from one language into another involves a certain amount of ambiguity which is in the nature of noise or loss of information and therefore one uses additional bits of information in the language of translation to overcome this noise. On the basis of this assumption one finds that a bit in English has about the same semantic value as 1·15 bits in German (which makes English slightly more efficient) and that each bit requires an additional 0·065 bits to overcome the noise inherent in the process of translation. Comparative studies in statistical aspects of Indian languages from the information theory point of view also showed the possibility of a common telegraph code for the Indian languages. One may go further and regard the different scripts as different codes for the same phonetic pattern and thus compare their efficiencies for transcribing from the verbal to the orthographic form.

Informational and Thermodynamic Entropies

A large part of our scientific activity may be described, in a sense, as seeking, processing and using information. A theory of information, therefore, cannot but be of some significance to science at least on the philosophical plane. Brillouin, who has some provoking statements to make, has explored the relationship between the thermodynamical entropy of a physical system and the amount of information obtained when the state of the system changes. When an isolated system is left to itself, according to the second law of thermodynamics, the system can undergo only those changes which lead to an increase in its physical entropy or a degradation of its energy. At best the entropy remains constant if the change is a reversible one. Brillouin argues that information can only be obtained by letting the entropy of the system increase and the increase in entropy is always greater than the amount of information obtained.

Consider a system whose initial state could result, for instance, from any of the W_0 equally probable complexions and hence *a priori* probability $p_0 = 1/W_0$ and initial entropy $S_0 = k \log W_0$, k being Boltzmann's constant. As the system degrades in the course of a natural change, its final state can result from any of the W_1 ($> W_0$), say, equally probable complexions with probability $p_1 = 1/W_1$, and its entropy becomes $S_1 = k \log W_1$. The change in entropy is

$$S_0 - S_1 = k \log_e (W_0/W_1) = k \log_e (p_1/p_0).$$

Information theory tells that an observation which involves a change in the probability from p_0 to p_1 brings $\log_2 (p_1/p_0)$ bits of information. We can, however, identify $k \log_e (p_1/p_0)$ itself with the amount of information I (by choosing a new unit of information) that could possibly be obtained from the system. Thus

$$S_1 = S_0 - I.$$

Brillouin now restates the second law of thermodynamics in a somewhat more generalized form by saying that "in any transformation of a closed system, the quantity entropy *minus* information must always increase or may at best remain constant" and hence argues that information can only be obtained from a system by letting its entropy increase. Notice that every observation is an irreversible one and hence involves an increase in the entropy in accordance with the above reasoning. Under the best of circumstances, the amount of information obtained is equal to the increase in the entropy so that in general

$$\Delta I \leq \Delta S.$$

Because of the opposite sign of information to entropy we might make use of information to decrease the entropy, but the overall balance still remains in favour of an increase in the entropy. Brillouin has seized upon this relationship to discuss the efficiency of an experimental observation which he defines as the ratio $\Delta I/\Delta S$ (< 1).

The concept of entropy and the second law of thermodynamics raised in the past many issues with philosophical implications which are still being debated. Information theory with its wide connections gives us a new opportunity to re-examine these questions afresh. Information theory is thus more than a theoretical tool for the evaluation of communication systems; it has already come to stay as a way of thinking about a very wide class of problems.

Literature on information theory is very extensive and widely scattered. We cite some references which will enable the reader to pursue his way through this subject.

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^{12}C AS REFERENCE NUCLIDE

THERE exist at present three scales of atomic masses of weights: (i) the absolute scale based on the gram, (ii) that defined by taking the mass of one atom of the nuclide ^{16}O equal to 16 units (the "Physical scale" of "atomic masses" or "nuclidic masses"), and (iii) that taking the average atomic masses of the isotope mixture of "natural" oxygen as 16 units (the "Chemical scale" of "atomic weights"). Of these, only the last two are in common and extensive use. The chemical scale is indefinite to the extent of the variation in the average atomic mass of oxygen from various natural sources (some 15 parts per million) resulting from variations in the relative proportions of ^{16}O, ^{17}O and ^{18}O.

Recently, proposals for improving this situation have been made and discussed. The necessity of matching the proper value of the Avogadro number with the mass values employed arises especially often in the domain of nuclear chemistry.

Proposals to unite the scales by adopting the physical scale for chemical atomic weights have been regarded with disfavour by many chemists because of the relatively large change, about 275 parts per million, which would have to be made in all of the quantities whose values depend on the size of the mole. There are many physicochemical data whose precision is greater than that and whose value would therefore have to be changed. On the other hand, the serious consideration which has been given by chemists to the proposal of a new unified scale based on $^{19}F = 19$, which would result in a change of 41 parts per million, indicates that many chemists would be willing to accept a unified scale if the atomic weights would not be changed by more than about this amount. There are relatively few chemical data bearing such high precision.

Fortunately, there is a possible scale definition which, as the basis of a unified scale, would suit chemists and by which, moreover, physicists would benefit greatly.

Evidently, that definition is to be preferred which allows most nuclidic masses to be expressed with the smallest errors, not only now but also in the foreseeable future. As is shown below, this purpose is fulfilled by taking ^{12}C as the reference nuclide. The best definition of the atomic mass unit is, accordingly,

Mass of ^{12}C equals exactly 12 atomic mass units. The unit defined in this way is 318 parts per million larger than the present physical mass unit and 43 parts per million larger than the present chemical one.

In the mass-spectroscopic determination of nuclidic masses, the most important substandard is ^{12}C. Not only do the doubly, triply, and quadruply charged atomic ions of ^{12}C occur at integral mass numbers so that they can be paired in doublets with nuclides having mass numbers 6, 4 and 3 respectively, but—much more important—no other element besides carbon can be found which forms molecular ions containing as many atoms of but one kind (up to 10 and more). Therefore, the scale $^{12}C = 12$ would allow many more direct doublet comparisons of masses, especially of heavy nuclides, with the reference nuclide than any other scale. 12-Carbon has the additional advantage that carbon forms many more hydrides than any other element, so that an easy reference line for doublets can be produced at almost every mass number up to $A \sim 120$. Many stable nuclides in the mass region $120 < A < 240$ can also be measured in reference to ^{12}C by pairing in doublets their doubly charged ions with singly charged ions of $^{12}C_n$ or of $^{12}C_nH_m$ fragments. Use can then be made of nuclear disintegration data to obtain accurate masses of many other, especially unstable nuclides.—*Science*, 20th June 1958, 127 (3312), 1431.

GEOTHERMAL POWER

THE concept of the economic development of geothermal energy is relatively new, for natural steam emanating from the earth in the form of geysers and fumeroles has been regarded traditionally as a scientific curiosity, and regions exhibiting such phenomena have been set aside as parks and tourist attractions. But in the last few years, a number of nations in many parts of the world have been re-evaluating their thermal areas as something more than mere spectacular scenery. For, in our modern mechanized society with its great dependence on fossil fuels as energy sources, the doubling and redoubling of power requirements in the post-war years has placed a heavy strain on these patently exhaustible resources. As a result energy sources which are essentially inexhaustible, such as falling water, nuclear fission, and geothermal steam, are receiving increased attention.

The theory supporting contentions that subterranean steam is a virtually inexhaustible resource is based on the conversion of both meteoric water and magmatic water to steam. Meteoric water, or ground water, contacting hot rocks near the surface is commonly held responsible for geyser phenomena and is certainly accountable for the occurrence of large quantities of steam; but it is magmatic water, reckoned at about 10% of the superheated earth's core and released upon cooling and crystallization of magma into igneous rock, that makes up the bulk of the steam reserve. Taking both of these sources into consideration, Italian scientists at Lardarello, Tuscany, where the pioneer project of this type has produced power for many years, have estimated that at the present rate of energy withdrawal from the proven geothermal area, reserves are sufficient for another 11,000 years.

However, despite the success of the Italian development and its expansion following the war, little attention had been paid to geothermal development until very recently, when a major project was begun in New Zealand [*Science*, 126, 440 (September 6, 1957)]. Taking advantage of an extremely favourable set of natural and economic circumstances on the North Island, the New Zealand Government in 1950 launched a widely publicized programme to utilize geothermal steam to produce electric power on a large scale. The apparent success in New Zealand (the schedule calls for initial power deliveries this year) triggered a rash of exploration and development schemes in a number of other widely scattered locations around the world. In Mexico, Iceland, El Salvador, Chile, Fiji, the British Windward Island of St. Lucia, and at the aforementioned Big Geysers, drilling programmes are in the planning stages or already underway.

The Big Geysers Project undertaken by a concern in Santa Rosa, Calif., is still in the early, speculative stage and the aim is merely to test the energy potential of the property by drilling at many different locations and varying depths. Only after the results are in on this exploration and testing, can plans be forthcoming for the economic utilization of the stream. Nonetheless, close observers exhibit a cautious optimism, pointing out that the eight old shallow wells, together with Magma No. 1, are blowing an estimated 6,000 kilowatts of energy into the air; to duplicate this in a modern power plant would require the burning of 240 barrels of fuel oil or 1,444,000 cubic feet of gas per day. Temperatures at the 500-feet level have been determined at 600°, and if the heat gradient continues to rise in proportion to depth 1,000-1,500-feet bores might be expected to have very high temperatures and yield at least the equivalent of 4,000 kilowatts per well (New Zealand wells have averaged 6,000 kilowatts). So far Big Geysers steam, even for existent shallow bores, has proved to be dry, in contrast to the wet steam found in other areas; wetness constitutes a turbine corrosion hazard. Further, engineering reports on the region state that wells can be drilled as close together as 150' without reducing the production of their neighbours, and that the ultimate potential of the property could easily exceed 30 wells, or 100,000 kilowatts, should a substantial portion of the property prove productive.

If such results can be achieved, geothermal steam can compete very favourably in power production. Geothermal steam shares with all other energy sources generating electric power, the long distance transmission line loss, but it has double advantage over hydrogeneration in not being subject to the vagaries of seasonal stream flow or the conflicting water requirements of irrigation *vs.* power development. Similarly, the sharp increases in fuel prices in the past few years, plus the need for boilers, which constitute 30-40% of overall power-plant costs, give geothermal steam a real advantage over standard thermal plants.—(*Science*, May 1958.)

LETTERS TO THE EDITOR

A METHOD FOR ESTIMATING THE ULTRASONIC VELOCITY IN SOLIDS

FROM the data obtained regarding the supersonic velocities in organic liquids, Rao[1] has suggested a simple relation

$$v^{1/3} \cdot \frac{M}{d} = R \qquad (1)$$

where v is the velocity of supersonic waves in the liquid of molecular weight M and density d. R is a constant independent of temperature. It was further observed that R is an additive function of the chemical constituents of the liquids.

In the case of liquid mixtures, this relation can be extended as follows:

$$R_{12} = v_{12}^{1/3} \cdot \frac{M_{12}}{d_{12}} \qquad (2)$$

$$R_{12} = R_1 x + (1-x)\, R_2 \qquad (3)$$

$$M_{12} = M_1 x + (1-x)\, M_2 \qquad (4)$$

where R_1 and R_2 are the values of R in the case of solute and solvent respectively and R_{12} that of the mixture. M_1 and M_2 are the molecular weights of the solute and solvent, while M_{12} is that of the solution, x being the molecular fraction of the solute, v_{12} is the velocity of supersonic waves in the mixture whose density is d_{12}. For the two constituents of the mixture, the values of R will be given by eq. (1).

The author has extended these results to the case in which the solute is a solid. Experimental results on the solutions of different concentrations of benzoic acid in ethyl alcohol, propyl alcohol, butyl alcohol and amyl alcohol are reported in a paper (Lal and Sharma[2]) and detailed results on the solutions of benzoic acid in benzene, xylene and toluene are to be reported elsewhere. It is found that Rao's equation can be extended to solid-liquid solutions and the mixture law as given by eq. (3) also holds good in the case of solid-liquid solutions.

Further, the values of the constant R for the solute (benzoic acid) have been calculated from above equations for the different concentrations of the solute and in different solvents. It is very interesting to note that these values of R are nearly the same for the same solute irrespective of the solvent. As we are getting the constant value for the solute (solid) in every case, we may extend Rao's equation

$$v^{1/3} \cdot \frac{M}{d} = R$$

to the case of solids and calculate the velocity of supersonic waves in the solute. The method is thus useful in estimating the ultrasonic velocity in a pure solid solute existing in a hypothetical liquid state at room temperature. The velocity in the case of benzoic acid comes out to be $3{\cdot}92 \times 10^5$ cm./sec. It will be quite interesting to test whether this velocity agrees with the value of the velocity in the solute in the molten and in the solid state.

The author expresses his very grateful thanks to Dr. P. N. Sharma for his guidance and encouragement.

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Lucknow University,
Lucknow, *May* 19, 1958.

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POLARIZATION STUDIES ON CHROMATE-TREATED ZINC

MUCH basic and significant information about the processes associated with corrosion inhibition can be obtained from polarization studies.[1,2] It is shown below that polarization data are helpful in elucidating the fundamental mechanism by which chromate treatment of zinc increases the resistance of this metal to corrosion.

Analytical data have shown that a film approximately 0·00002" thick of basic chromium chromate of general formula Cr_2O_3, CrO_3, nH_2O is formed on the metal surface during Cronak process.[3] The hexavalent chromium in this film, which is slightly soluble, is leached into the corrosive medium and protection to the metal surface is believed to be obtained both by the well-known inhibiting action of hexavalent chromium in solution and by the insoluble, presumably, trivalent chromium film left on the metal surface.[4]

Fig. 1 shows polarization curves obtained shortly after immersion of untreated and chro-

mate-treated zinc in 0·001% NaCl solution and of untreated metal in solution containing 0·001% NaCl + 500 p.p.m. of sodium chromate. Fig. 2

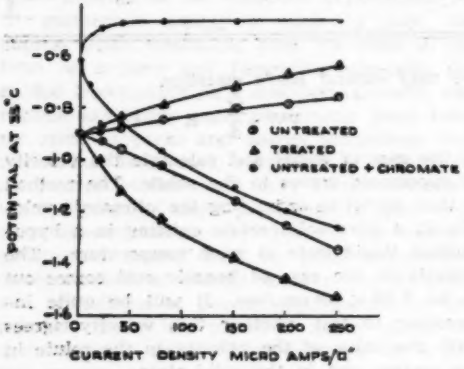

FIG. 1. Polarization curves of untreated and chromate-treated zinc in 0·001% NaCl and untreated zinc in 0·001% NaCl + 500 p.p.m. chromate.

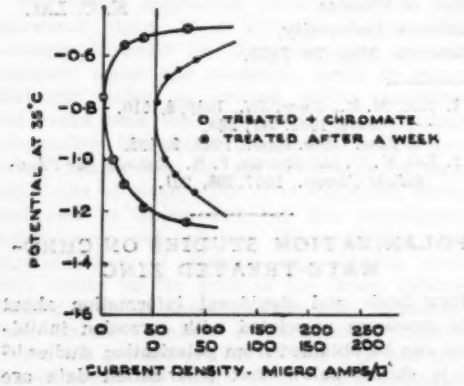

FIG. 2. Polarization curves of chromate-treated zinc in 0·001% NaCl (after a week) and in 0·001% NaCl + 500 p.p.m. of chromate.

shows polarization curves obtained with chromate-treated zinc in (1) 0·001% NaCl + 500 p.p.m. sodium chromate shortly after immersion, and (2) in 0·001% NaCl solution only after immersion for a week. 1" × 1" specimens of the metal were used in the study and the potentials were measured by the Poggendorf method, using a Beckman pH meter as null point indicator.

It may be seen from Fig. 2 that (1) the polarization curve of chromate-treated metal after the lapse of a few days, and (2) polarization curve of chromate-treated metal just after immersion in potassium chloride solution containing hexavalent chromium in addition, both show considerable similarity, lending support to the view presently held regarding the mechanism of inhibition. The formation of the film itself markedly increases both anodic and cathodic polarization (Fig. 1) and the potential of the metal, therefore, remains more or less unchanged, as predicted by Mears.[2] Hexavalent chromium in solution further increases anodic polarization and thus reinforces the protective action of the film itself. As pointed out in an earlier note,[5] increased polarization may mean either changes in the anodic and cathodic areas of the local cell or changes in the specific reaction velocity factors for the anodic and cathodic reactions. It is not unlikely that film formation brings about profound changes in the anodic and cathodic areas and hexavalent chromium in solution affects the velocity factor of the anodic reaction.

Thanks of the authors are due to Dr. K. S. G. Doss, Director, Central Electrochemical Research Institute, for his suggestions and encouragement in carrying out the above study.

Central Electrochemical Res. Institute, Karaikudi, *May* 8, 1958.

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CHEMICAL INVESTIGATION OF *CORIANDRUM SATIVUM*

THE plant *Coriandrum sativum* (N.O. Umbelliferræ) is widely distributed throughout India and grows widely also in Palestine, Syria, Mesopotamia and Greece. Both in the Ayurvedic as well as in Yunani system of medicine, it is recommended in bronchitis, biliousness, syphilis, dyspepsia.[1] The essential oil of the fruits of this plant has been worked out by a number of workers and various constituents have been identified.[2] The main constituent is coriandrol or linalool.[3] Apart from the essential oil, which is used as a carminative, no other systematic work has been carried out.

In the present work, the dried and powdered fruits of this plant have been extracted with ethyl alcohol (95%) by percolation at room temperature. This alcohol extract after concentration has been re-extracted successively with

light petroleum (40-60°), ether, benzene, chloroform, and ethyl acetate.

From the light petroleum extract, a new triterpene derivative which has been named 'coriandrinol', m.p. 302-04° (vacuum) and a mixture of sugars (glucose, fructose and sucrose) have been isolated. The extract on chromatography over alumina has furnished also a sterol, m.p. 143-50°. (acetyl, m.p. 126-30°, benzoyl, m.p. 133-37°) probably β-sitosterol or stigmasterol and a yellow oil, b.p. 312-15°. The benzene extract did not give any definite product other than coriandrinol.

The ether and chloroform extracts have also furnished phenolic as well as acidic products, working up of which is in progress.

Institute of Science, Bombay, *May* 23, 1958. (MISS) D. D. VAGHANI. *V. M. THAKOR.

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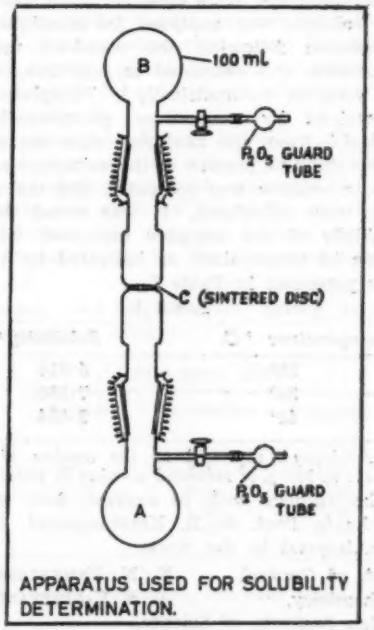
SOLUBILITY OF PHOSPHORUS OXYCHLORIDE-ALUMINIUM CHLORIDE COMPLEX

IN the course of our investigations on the physico-chemical properties of complexes formed by phosphorus oxychloride with metallic chlorides, it became necessary to determine the solubility of the complexes prepared under a variety of conditions in non-aqueous solvents such as nitrobenzene and acetonitrile. Such a determination by ordinary procedure presents certain experimental difficulties. Both the reactants and the resultant product are extremely hygroscopic. The solvent such as nitrobenzene and water are practically immiscible; however, nitrobenzene has great avidity for moisture which it readily absorbs from atmosphere.[1] The presence or entry of moisture in any form at any stage of the experimental procedure vitiates the result. Therefore, all the operations have to be carried out in moisture-free atmosphere in a dry-box. The following method using the apparatus described below was developed to determine the solubility of the complex prepared from anhydrous aluminium chloride and phosphorus oxychloride. The complex was prepared by mixing a definite quantity of anhydrous aluminium chloride and excess of phosphorus oxychloride. The mixture was warmed up to 95° C. taking care to protect the reactants in the flask from atmospheric moisture using appropriate guard tubes containing phosphorus pentoxide. After cooling the resulting homogeneous solution to room temperature, the excess of phosphorus oxychloride was removed by evaporation under vacuum. The residue left behind was a colourless free-flowing powder. On analysis, the compound was found to correspond to a complex with the composition $AlCl_3 2\,POCl_3$. The samples of this compound could be stored in ampoules sealed under dry conditions.



APPARATUS USED FOR SOLUBILITY DETERMINATION.

FIG. 1

A definite quantity (about 2·5 g.) of the complex was introduced into the flask A (as shown in Fig. 1) and a known volume (25 ml.) of pure and dry nitrobenzene[2] was added. The apparatus was assembled and all the leads from the stopcocks were protected from moisture by phosphorus pentoxide tubes. The flask was kept in a thermostat at the desired temperature for 24 hr. and the flask frequently shaken to obtain a saturated solution. At the end of 24 hr. the apparatus was removed from the thermostat and inverted to filter the saturated solution through the sintered disc C and to remove the excess of the solid. Since the time required to filter through the disc was only of the order of a couple of minutes, it was fiund unnecessary to filter the solution in the thermostat

using a more elaborate piece of apparatus. The results were found to be reproducible within an accuracy of 1%. An aliquot portion of the saturated solution was weighed and shaken with distilled-water (50 ml.). The complex hydrolysed forming phosphoric acid and hydrochloric acid along with aluminium chloride. These remained in the aqueous layer. The nitrobenzene layer was separated and repeatedly washed with fresh quantities of distilled-water till the washings were free from acid. The washings and the original extract were mixed and made up to a volume (250 ml.). The solution was analysed for aluminium and phosphorus following the standard methods. Aluminium was estimated as 8-hydroxy quinoline complex volumetrically.[3] Phosphorus was determined by ammonium phosphomolybdate method.[4] From the analytical data the amount of the complex present in the saturated solution of nitrobenzene was computed and the solubilities were calculated. It was found that the solubility of the complex increased with increase in temperature as indicated by the results presented in Table I.

TABLE I

Temperature °C.	*Solubility**
25°	5·910
30°	7·250
40°	8·634

* Solubility is expressed as the number of grams present in 100 g. of saturated solution in nitrobenzene.

The authors wish to express their grateful thanks to Prof. K. R. Krishnaswami for his keen interest in the work.

Dept. of General Chemistry, Indian Institute of Science, Bangalore, *May* 27, 1958.

K. N. VENKATARAMAN.
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SOLVOLYSIS OF 1-PHENYL-*n*-PROPYL CHLORIDE

IT has been found that 1-phenyl-*n*-propyl chloride undergoes solvolysis in aqueous acetone and aqueous ethanol at rates which are about 25-36% of the corresponding rates for 1-phenylethyl chloride (Table I). The temperature is 50° C. throughout.

TABLE I

Solvent*	$(10^5 k_1$ (sec.$^{-1}$)	
	CHPhEtCl	CHPhMeCl
80% aq. ethanol ..	6·60	16·9†
70% do. ..	18·6	56·0†
60% do. ..	45·1	169·0
80% aq. acetone ..	0·310	1·25‡
60% do. ..	7·80	25·4‡

* "X%" aqueous ethanol or acetone signifies solvent made up of X volumes of the organic solvent and (100−X) volumes of water.

† Values from Fainberg, A. H. and Winstein, S., *J. Amer. Chem. Soc.*, 1957, **79**, 1597.

‡ Calculated from data of Hughes, E. D., *et al.*, *J. Chem. Soc.*, 1937, 1201, using E_A values given by Grunwald, E. and Winstein, S., *J. Amer. Chem. Soc.*, 1948, **70**, 846.

The reverse order for the rates of solvolysis would be expected on the basis of the relative inductive effects of the methyl and ethyl groups. The inversion of the order is presumably due to the dominating influence of the hyperconjugative effect. One point which requires explanation is the large magnitude of the hyperconjugative effect, which is surprising, because the alkyl group is directly attached to the seat of substitution, and not through a highly polarisable system such as a system of conjugated double bonds. In explanation, it is suggested that the phenyl group contributes to the stabilisation of the transition state by allowing a fuller use of the hyperconjugative resonance energy.

Applied Chem. Div., Trivandrum, *May* 8, 1958.

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OBSERVATIONS ON THE ROLE OF METHIONINE IN EXPERIMENTAL MALARIA (*P. GALLINACEUM* IN CHICK MALARIA)

FOLLOWING the observations of Moulder and Evans,[1] that cell-free extract of *P. gallinaceum* contained certain proteases which hydrolyses the globin and on the utilisation of a considerable part of the amino acids obtained by hydrolysis for the synthesis of parasitic proteins and that of Mckee and Geiman[2] on the requirement of methionine for the satisfactory *in vitro* growth of *P. knowlesi*, systematic study of the amino acid changes in the blood of chicks infected with *P. gallinaceum* has been undertaken in this laboratory.[3]

The follow-up by the chromatographic techniques of the amino acid make-up of the whole blood, plasma and erythrocytes of normal and parasitised animals has revealed a decrease of combined methionine in the whole blood during incubation and an increase at the height of parasitæmia. Its distribution amongst the constituents of the blood shows that in plasma there is a steady decrease while in the erythrocytes a continuous increase from the time of infection. Free methionine, on the other hand, is seen to increase in the whole blood throughout the course of infection, plasma exhibiting a slight initial increase followed by a decrease while in erythrocytes the inverse relationship is observed[4] (Table I).

Recent *in vitro* studies of *P. knowlesi* by Fulton and Grant[5] using labelled S^{35} methionine shows that 80% of methionine in the parasite protein is obtained from that in the red cell globin. This explains the marked increase of methionine in the parasitised erythrocytes of chicks.

Studies on the supplementation of methionine to infected birds showed an earlier onset of parasitæmia and an increased severity of infection compared with the controls (Table II).

The findings of Cohen *et al.*[6] that dietary methionine accelerates the turnover of hæmoglobin probably explains the early onset of parasitæmia and increased severity of infection in methionine supplementation studies noticed in our experiment.

Administration of ethionine, a well-known antimetabolite of methionine at a dose level of 10 mg./100 g. body weight to infected chicks prolonged the prepatent period and showed a decreased severity of infection. The findings in individual birds in one set of experiment is shown in Table II.

Taylor[7] has found a 50% reduction in parasitæmia in mice infected with *P. berghii* when treated intraperitoneally with ethionine.

Studies in rats made by Chung Wa and J. L. Bollmann[8] show that ethionine impairs the utilisation of methionine by the body and causes

TABLE I

Free and combined methionine in the whole blood, plasma, and erythrocytes during the course of malarial infection (P. gallinaceum *in chicks*)

Specimen	Combined*			Free amino acid†		
	Normal	Incubation	Parasitised	Normal	Incubation	Parasitised
Whole blood ..	1·0	0·6	1·3	2·7	3·4	5·5
Plasma ..	0·5	0·3	0·1	3·12	3·44	3·33
Erythrocytes ..	0·3	0·7	1·4	2·73	1·30	2·10
Liver ..	0·9	0·7	0·3	3·30	1·30	3·20

* Results expressed as percentage of nitrogen.

† Results expressed in micrograms per 147 microlitres of each of the extract made up to the same volume in each case.

TABLE II

Effect of supplementation of methionine and ethionine on experimental Avian malaria (P. gallinaceum *in chicks*)

	No. of birds	Dose and Route	Parasitæmia on the day of infection								Remarks
			5th	6th	8th	9th	10th	11th	12th	14th	
1 Untreated infected chicks	3	..	..	0·5	14	..	22	D	..	..	..
			..	0·4	10	..	18	D	..	..	
			..	1·0	20	D	..	..	..	..	
2 Infected chicks treated with methionine	3	70 mgm. per 100 gm. body wt. I.M.	0·2	2	..	..	12	..	D	..	Earlier appearance of parasites observed
			16	50	..	..	D	..	..	..	
			0·6	8	..	..	9	D	..	..	
3 Infected chicks treated with ethionine	3	10 mgm. per 100 gm. body wt. I.M.	..	..	..	5	..	8	D	..	Has suppressive effect
			..	..	0·2	8	..	12	..	D	
			..	..	..	0·1	..	10·3	D	..	

D = Death.

a greater excretion of the latter in the urine. This antagonism of an essential metabolite to the parasite may also explain the suppressive effect of ethionine noticed in *P. gallinaceum* infection of chicks and of *P. berghii* of rats.

The detailed report will be published elsewhere.

Our thanks are due to Dr. K. P. Menon for his helpful suggestions during the investigation.

Pharmacology Lab., Indian Inst. of Science, Bangalore-3, *May* 15, 1958.

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POTENTIOMETRIC DETERMINATION OF THERMODYNAMIC FUNCTIONS OF DISSOCIATION OF GALLIC ACID

In the previous communication, the authors reported the determination at 298 A of the dissociation constant (K) of gallic acid [$C_6H_2(OH)_3COOH \rightleftarrows C_6H_2(OH)_3COO^- + H^+$][2,3] which is used as an analytical reagent for Th^{++}, Cu^{++}, Al^{+++}, etc.,[4] and which contributes in part, to the colour and acidity of sugarcane juices.[5] These studies have now been extended to the determination of K at different temperatures in the range 300-60 A, and of the thermodynamic quantities like change in free energy, entropy, etc., on which no data exist in the literature.

Gallic acid of B.D.H. quality was recrystallised several times in distilled-water till the final product gave constant melting point (252° C.) carbonate-free sodium hydroxide was used. A known volume of gallic acid solution of desired concentration was titrated potentiometrically against standard NaOH solution using glass and calomel electrodes. The titration was carried out in an inert atmosphere. The variation of the temperature of the reaction vessel was ± 0·1° C.

A typical set of data on the values of K obtained at different temperatures is given in Table I; column 3 gives the values of thermodynamic dissociation constant K calculated from the equation

$$\log K = \log K - 2A \times \sqrt{\mu} \qquad (1)$$

which follows from the well-known Debye-Huckel limiting formula. The results in Table I

TABLE I

Determination of dissociation constant of gallic acid at different temperatures

Temp. (Å)	Classical Dissociation Constant (K') $\times 10^5$	Thermodynamic Dissociation Constant (K) $\times 10^5$
303	3·84	3·396
313	3·76	3·196
323	3·61	3·113
333	3·44	2·917
343	2·69	2·278
353	2·23	1·812

indicate that K decreases with temperature (see Fig. 1); and the corresponding variation

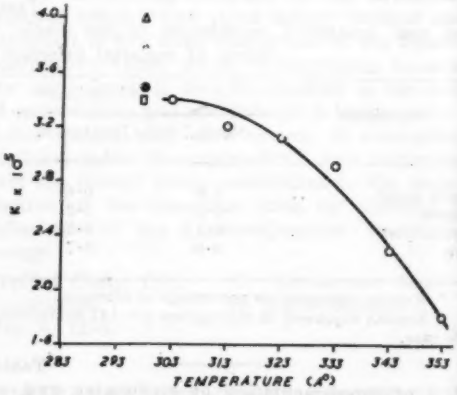

FIG. 1. Variation of the thermodynamic dissociation constant, K with temperature.
● —Due to Ramaiah and Gupta (Ref. 1); × – Ostwald (Ref. 2);
□ – Magnaini (Ref. 3); △ – Tomicek (Ref. 6).

could be expressed by the following equation:

$$-\ln K = A/T + B + CT \qquad (2)$$

where A, B and C are constants with the following values:

$A = 272{\cdot}08$;
$B = 4{\cdot}81$;
$C = 1{\cdot}49 \times 10^{-2}$.

From equation (2) are obtained the values of the change of free energy (ΔF), heat content (ΔH), entropy (ΔS) and heat capacity (ΔCp) of the dissociation of gallic acid; these are given in Table II.

TABLE II

Thermodynamic quantities of dissociation of gallic acid

Temp. (A)	ΔF I.J. Mole^{-1}	ΔH I.J. Mole^{-1}	ΔS I.J. Mole^{-1}	ΔCp I.J. Mole^{-1}
303	59237	−20896	−264·5	−172·5
313	61887	−22675	−270·2	−178·2
323	64635	−24487	−275·9	−183·9
333	67419	−26353	−281·6	−189·6
343	70250	−28277	−287·3	−195·3
353	73164	−30235	−293·0	−201·0

The details will be published elsewhere.

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Kanpur, *May* 6, 1958. R. K. CHATURVEDI.

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NITROGEN CONTENT AND YIELD OF SOME SUGARCANE VARIETIES

ON the basis of the thorough investigation of the chemistry of sugar-producing plants, O. W. Willcox[6] formulated in 1928 the 'Inverse Yield Nitrogen Law in Agriculture', according to which, "Of two or more kinds of plants grown concurrently under the same normal conditions, the one with the smallest per cent. of nitrogen will yield the largest quantity of dry vegetable substance". Since then much evidence has accumulated on the yield potential of sugarcane varieties as an inverse function of their nitrogen content. Fort and Holmes[4] of Louisiana, Carreras of Peru[2] and Beaucnamp of Cuba[1] have produced evidence in support of this theory. Although Dutt and Aiyar[3] of Coimbatore, and Vallance[5] of Queensland have produced data which deviate from this relationship, it may be pointed out here that many of the varieties on which these latter workers worked, behaved in consonance with the Willcox's postulate.

We noted the inverse relationship of the nitrogen content of some varieties of sugarcane with their yielding ability at the Indian Institute of Sugarcane Research, Lucknow, in 1957-58. Varietal trials have been under progress in the Agronomy Section at this Institute since 1954-55, wherein yield data of five varieties (Co. 453, Co. 997, Co. 617, Co. 957 and Co. 313) for four years, *e.g.*, 1954-55, 1955-56, 1956-57 and 1957-58 are available. On examining these data critically for three years, it was observed that the relative yield of these varieties excepting the variation that is usual in field trials, has been more or less on the same pattern. To test whether their yield behaviour could be explained on inverse yield-nitrogen relationship, cane stick samples were taken from these varieties on the day the varietal trial of 1957-58 was harvested. Their nitrogen content was determined and the result expressed on oven-dry basis. The nitrogen content (1957-58) and the average yield of cane stick in maunds per acre of these varieties for four years have been given in Table I.

TABLE I

Percentage nitrogen (1957-58) and yield of five varieties of sugarcane for four years

Varieties	Mean percentage Nitrogen in cane stick 1957–58	Average yield of cane in maunds per acre for four years
Co. 453 ..	0·34±0·00	752·4 ± 108·60
Co. 997 ..	0·35±0·01	604·9 ± 130·67
Co. 617 ..	0·39±0·01	558·3 ± 128·85
Co. 957 ..	0·41±0·01	531·0 ± 114·82
Co. 313 ..	0·45±0·00	379·4 ± 23·60

From the table it is evident that the yield behaviour of these varieties is in conformity with the inverse yield-nitrogen relationship, indicating that under the soil and environmental conditions of the growth of these varieties, their yield potential was determined, to a great extent, by their nitrogen content.

As this finding has some implication in the selection of varieties at early stages of selection, we are planning to investigate this relationship for a large number of varieties in future.

Our thanks are due to Dr. J. T. Rao, Agronomist, for kindly providing us yield data of these varieties.

Soil Chemistry Section, Indian Institute of Sugarcane Research, Lucknow, *June* 9, 1958.

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HITHERTO UNRECORDED OCCURRENCE OF *DATURA INNOXIA* MILL. IN THE UPPER GANGETIC PLAIN AND THE RAJASTHAN DESERT

IN the Upper Gangetic Plain, only three species of *Datura* are known to occur, *viz.*, *D. suaveolens* H. and B. (Raizada[1]), *D. metel* Linn. and *D. stramonium* Linn. (Duthie[2]). The last two species are the only ones recorded from the Rajasthan desert.

D. innoxia Mill., syn. *D. metel*, auctt. (non-Linn.), can be easily distinguished from other species of *Datura* by the presence of greyish tomentum on the whole plant; 10-toothed corolla, and long slender spines on the capsule that dehisces irregularly.

As pointed out by Santapau,[3] this species has been wrongly mentioned as *D. metel* in most of the Indian Floras. Duthie, describing this species under the name of *D. metel* Linn. in the flora of the Upper Gangetic Plain and of the adjacent Siwalik and Sub-Himalayan tracts wrote,

"I have seen no record of this species within the limits of this flora, though probably occurring near habitations in Sub-Himalayan tracts." Similarly there is no record of this species in the floristic literature of the Rajasthan desert.

The present author, however, found this species quite commonly in Lucknow Dist. and elsewhere in the Upper Gangetic Plain, growing scattered near habitations in waste lands and near water. In the Rajasthan desert it was noticed to occur on stabilized sand dunes. At Sambhar Lake, this species was found on the banks of small ponds in which the brine is collected to crystallize out the salt. In these halophytic specimens, the roots were rather swollen.

The absence of any record of this species in the earlier floristic literature of these regions seems to indicate that most probably this species has been introduced in these regions rather recently.

I am highly thankful to Dr. R. N. Lakhanpal for going through the manuscript.

Birbal Sahni Institute of Palæobotany, 53, University Road, Lucknow, *June* 6, 1958.

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RECORD OF A NEW PHOLAD, *PENITELLA* SP., FROM SHINGLE ISLAND (IN THE GULF OF MANNAR) WITH A NOTE ON ITS DISTRIBUTION

PREVIOUS workers[1–5] have recorded, so far, four pholads, *Jouannetia*, *Pholas*, *Pholadidea* and *Martesia*, from Indian waters. During a collection trip, in September 1956, two specimens of *Penitella* sp. *Valenciennes*, buried in coral rock, were recovered from Shingle Island in the Gulf of Mannar.

The shell is oval in outline measuring 30 mm. in length and 17 mm. in breadth. A distinct umbonal-ventral sulcus dividing the shell into two regions is present. The callum is well developed. The protoplax is absent and the mesoplax is transverse in one piece. The metaplax and hypoplax are characteristically absent.

Turner[6] states that this pholad, so far as now known, is restricted in its distribution to the Eastern and Northern Pacific. The present record of this genus tends to show its further distribution in Indian waters.

Our thanks are due to Dr. Ruth D. Turner, Museum of Comparative Zoology, Harvard University, for identifying the pholad.

Dept. of Zoology, Andhra University, Waltair, *January* 27, 1958.

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MATING TYPES IN *STYLONYCHIA PUSTULATA*

FOLLOWING Sonneborn's discovery of mating types in *Paramecium aurelia*, in 1937,[1] mating types were found in other species of *Paramecium* (Jennings, 1939[2]; Gilman, 1939[3]; and Giese, 1939[4]) and in *Euplotes patella* (Kimball, 1939[5]). More recently mating types have been reported in *Stylonychia putrina* (Downs, 1952[6]), *Tetrahymena pyriformis* (Elliot and Gruchy, 1952[7]; Nanny and Caughey, 1953[8]) and *Oxytricha bifaria* (Siegel, 1956[9]). In addition to these species Sonneborn (1941[10]) interprets the observations of Maupas as indicating that mating types actually occur in *Stylonychia pustulata*, *Leucophrys patula*, *Onychodromus grandis* and *Loxophyllum fasciola*. But no attempt seems to have been made to study mating types in these four species. This article is designed to outline the general features of mating types in *Stylonychia pustulata*.

Detailed investigations in *Paramecium aurelia* (Sonneborn, 1947[11]) revealed only two mating types in a variety while in *Paramecium bursaria* (Jennings, 1939[2]), *Euplotes patella* (Kimball, 1939[5]), *Tetrahymena pyriformis* (Nanny and Caughey, 1953[8]), and *Oxytricha bifaria* (Siegel, 1956[9]), revealed more than two mating types in each variety. Examination of a number of stock cultures of *Stylonychia pustulata* has revealed the occurrence of three varieties and eight mating types. These have been designated in Roman numericals. The breeding relations are shown in Table I.

TABLE I

System of breeding relations in Stylonychia pustulata

Variety	Mating type	1		2				3	
		I	II	III	IV	V	VI	VII	VIII
1	I	−	+	−	−	−	−	−	−
	II	+	−	−	−	−	−	−	−
2	III	−	−	−	+	+	+	−	−
	IV	−	−	+	−	+	+	−	−
	V	−	−	+	+	−	+	−	−
	VI	−	−	+	+	+	−	−	−
3	VII	−	−	−	−	−	−	−	+
	VIII	−	−	−	−	−	−	+	−

The material was collected from canals and ponds of several localities, including two neighbouring towns, Vizianagram and Anakapalli. The mass cultures were maintained in wheat grain infusion and the clones in beef extract medium, described by Baitsell (1912[12]). No difficulty was experienced in maintaining the cultures. For ascertaining the mating types the clones were mixed in all possible combinations and the complimentary mating types made out from the mating reaction. Each mating type is defined by its unique property to mate with the opposite mating type.

Pairs appeared in the suitable combinations of the clones in 3-4 hr. after mixing. The near exhaustion of food after a well-fed condition appeared to be an essential prerequisite for pairing as pointed out by Kimball (1939[5]) for *Euplotes patella* and for this reason a drop of culture medium was added after the clones were mixed. When the organisms were numerous the food is immediately exhausted and pairs soon appeared. When different mating types were mixed, no agglutinative reaction was observed and the mating reaction was similar to *Stylonychia mytilus* described by Grell (1951[13]).

Encystment was observed in the stocks of variety 1 and 2 and preliminary investigations revealed the occurrence of autogamy in variety 1. Selfing was observed in a few instances in the mating type IV and detailed investigations on these problems will form the subject-matter of another communication.

The author wishes to express his thanks to Prof. P. N. Ganapati for the constant help and criticisms received throughout the course of this work.

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THE OCCURRENCE OF SCYPHISTOMA LARVAE IN VISAKHAPATNAM HARBOUR

ALTHOUGH some information is available on the occurrence and distribution of Scyphomedusæ in the Indian Seas[2-5,8-12] there is no published account of the development of any of the Indian forms.

While engaged in a study of the Fouling Organisms of the Visakhapatnam Harbour, we suddenly encountered a number of Scyphistomæ on a test-panel, at Station C⁰, which was heavily fouled by the Serpulid worm, *Mercierella enigmatica* Fauvel, during the period June-July 1957. They were found epizoic on the shells of the Serpulids as well as directly attached to the panels.

The Scyphistoma (Fig. 1) has a cup-shaped body terminating distally in an oral disc bordered by a circlet of tentacles surrounding the

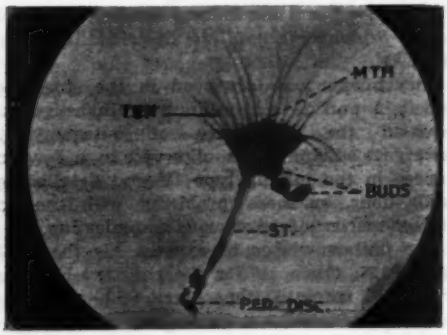

FIG. 1. MTH = Mouth; TEN = Tentacles; ST. = Stalk; PED. DISC. = Pedal Disc.

mouth. The lips of the mouth project a little beyond the bases of the tentacles. The body is drawn out into a stalk which ends in a flattened and well developed pedal disc. The stalks are long and muscular and the pedal discs apparently secrete a substance which makes the animal adhere to the substratum. The number of tentacles varied from 14-30 depending on the stage of development. The entire body surface including the tentacles and the stalk was covered by very long cilia. All the Scyphistomæ were profusely budding. The buds arise from the body-wall at about the junction of the stalk with the body. They first appear as knob-like outgrowths (Fig. 1) which later constrict themselves off from the parent after attaining appreciable sizes, but before any significant development has taken place. The type of budding observed corresponds to Type I reported by Berrill.[1] As many as four buds might appear at a time in the same Scyphistoma. In some cases the buds may form in chains of two or three (Fig. 1) when the total number may exceed four. The buds after detachment from the parent actively swim for about 48 hours aided by the long body cilia and then attach themselves by the end which is opposite to the base of constriction from the parent. The mouth and tentacles develop at the distal end, after attachment. These forms disappeared as suddenly as they appeared, perhaps due to sudden lowering of salinity, consequent on heavy rains during August. They again made their appearance on the panels suspended during January-February 1958, at the same location.

In December 1957, we obtained a second type of Scyphistomæ attached to barnacle shells and test frames suspended at the local Naval Base. These specimens were smaller than the first type collected from Station C. They also lack the typical stalk characteristic of the previous forms and the type of budding was entirely different. They were exhibiting the fig-type buds, pedal stolons (Fig. 2) and the Hydra-type buds described by Gilchrist[7] for *Aurelia*.

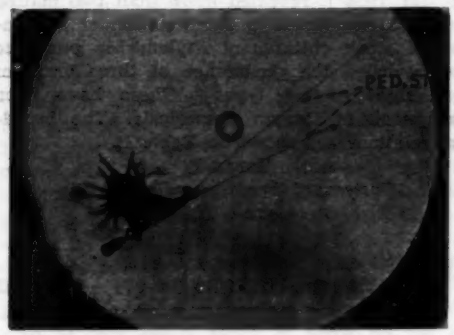

FIG. 2. PED. ST. = Pedal Stolon.

The formation and growth of the pedal stolons was also similar to those described by Gilchrist. The type of budding described for the Station C specimens was conspicuously absent in these forms. We have not obtained ephyræ from either of the two types though they lived for one month in a healthy condition in the laboratory.

While it is essential to procure the ephyræ of the two types of Scyphistomæ described, before their identity could be correctly established, it seems to us, fairly certain that they may belong to different genera. The Scyphistomæ collected from the Naval Base may belong

to *Aurelia* as already mentioned. Of the three species of *Aurelia* recorded from Indian waters, *A. aurita*,[10,12] *A. maldivensis*[2,10] and *A. solida*,[5,8,10–12] the last one has a wide distribution in the Indian Seas. Rao[12] has recorded a single specimen of *A. solida* from the backwaters of Visakhapatnam in the vicinity of the Harbour area. It is likely that our Naval Base forms may belong to this species.

The well developed stalks and pedal discs, the number of tentacles and the simple type of budding of the Scyphistomæ collected from Station C suggest that they may belong to either of the three genera, *Cyanea*, *Cassiopea* and *Chrysaora* (Berrill[1]), all of which have been reported from the Indian Seas. *Acromitus flagellatus* is also another very common Scyphomedusa in the coastal waters of India, the development of which is unknown at present.

Incidentally this is the first report of Scyphistomæ on fouling panels (see "Marine Fouling and Its Prevention" for species of Foulers recorded[13]).

Further details of reproduction and budding are being worked out and will be published elsewhere.

We thank Dr. W. J. Rees of the British Museum of Natural History for commenting on our Station C specimens.

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ABNORMAL POLLEN TUBE DEVELOPMENT IN A *NICOTIANA* HYBRID

INSTANCES are on record relating to multiple tube formation in pollen grains and also their forking during elongation (Maheshwari, 1950). Such occurrence has been reported to be frequent in members of the group Amentiferæ, where the extreme condition of ramification of the tube seems to have been met with. In the genus *Nicotiana* itself, Goodspeed is reported to have cited cases where more than one tube from a pollen grain entered the embryo-sac. Dusseau (1944) also reports bifurcate pollen tube in amphidiploid *N. suaveolens* × *N. glutinosa* and *N. glutinosa* × *N. sylvestris* hybrids. To augment the instances already reported and also as the phenomenon occurred in unusually high frequency in the present case, the following note on the abnormal pollen tube development in *N. longiflora* × *N. alata* hybrids is submitted.

The F_1 hybrid is almost sterile with about 20% of stainable pollen grains which failed to germinate on stigma of the self same flower or that of other hybrid flowers or of the parents. With a view to determine the cause for their failure to function, germination tests in agar-sucrose medium were conducted. While the grains were apparently inactive on the stigma, tube formation in the medium was very vigorous and they developed even as early as 4 hr. after dusting. The percentage of germination was found to be well over 90. However, only about 50% of the grains produced normal tubes while the rest were abnormal as indicated in Table I.

TABLE I
Germination in agar medium

S. No.	Type of abnormality	No. of grains	Reference
1	Normal ..	47	
2	More than one tube per grain ..	14	Pl. I
3	Forking of tube near the base ..	11	Pls. II & III
4	Forking of tube in the middle ..	8	
5	Forking of tube at the distal end	4	
6	Finger-like protuberance ..	6	
7	Hyphæ-like ramifications ..	3	
	Total: Normal—47; Abnormal—46		

The parental pollen were sown under similar conditions and normality was recorded to 100%.

Forking of the tubes take place either near the pollen grain (Plates II and III) or at the distal end. The arms always contain cytoplasmic materials. Meiosis in the hybrid which has

been found to be irregular (*N. longiflora*, $n = 10$; *N. alata*, $n = 9$ and hybrid $2n = 19$) resulted in heavy tetrad abortion and the pollen fertility is therefore reduced to 20-30%.

Tests on pollinating the hybrid and parental stigma with the hybrid pollen and *vice versa* revealed that a few grains germinated on the stigma with or without the help of agar medium and that abnormalities of tube development also occurred on the stigma even in the absence of any medium.

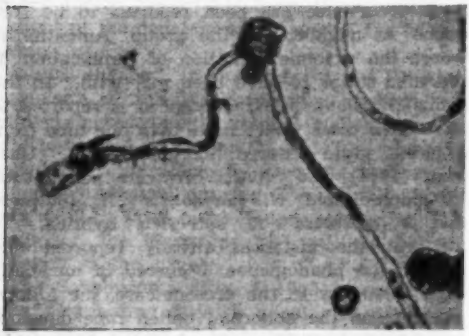

PLATE I

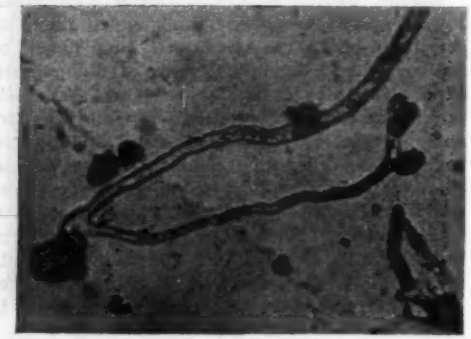

PLATE II

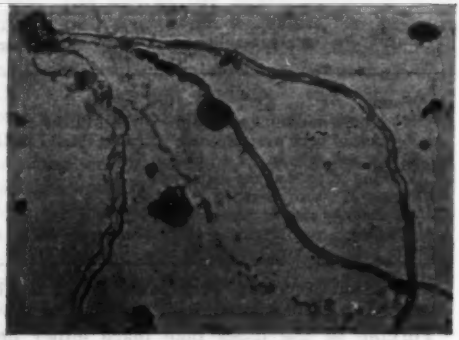

PLATE III

PLATE I. Two well-developed tubes from a single grain.

PLATES II & III. Tube forking.

Two facts need to be explained in the above hybrid, namely, (1) the cause for sterility, and (2) the abnormal tube production. Regarding the former, the available good pollen grains in the anther is very little and the possibility of all of them reaching the stigma is remote. Even reaching the stigma their germination is possibly prevented due to hybrid incompatibility as a result of which they remain as they are on the stigma. Even the few grains that were viable produced only short tubes which could not penetrate the style. Further, it may be noted that the grains equally failed to germinate on parental stigma. It would therefore mean that the apparently good grains are mostly non-functional. Added to this, the style and stigma of the F_1 may be incompatible for pollen tube development. How far ovule sterility also exists, needs further investigation and work is under way.

Regarding the production of abnormal tubes, it would appear that abnormalities occur with a higher frequency in agar medium (Table I) but also it is occurring even in the absence of the medium on the stigma. To suppose that agar medium would have acted as a mutagenic stimulant had to be ruled out since pollen of parental species as well as those of others, germinated in the medium, developed normal tubes. It would therefore mean that the abnormal pollen tube growth might be the characteristic of the hybrid pollen and is supported by the evidence cited by Sarana (1934) and Dusseau (1944). Such abnormal tube development may be adding to the sterility of the hybrid.

The authors wish to express their thanks to Dr. N. R. Bhat, Director, Tobacco Research, for the keen interest he has evinced during these investigations and offering valuable suggestions.

Central Tobacco Res. Institute, Rajahmundry, *May* 5, 1958.

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STUDIES ON THE DIETARY REQUIREMENTS OF THE HIDE BEETLE (*DERMESTES MACULATUS* DEGEER, DERMESTIDÆ: COLEOPTERA) WITH PARTICULAR REFERENCE TO AMINO ACIDS AND VITAMINS

THE hide beetle (*Dermestes maculatus* Deg.) is of international importance as a troublesome pest of dried fish, cheese, ham, hides and hide-products. In literature, *Dermestes vulpinus* Fab. is more often reported than *Dermestes maculatus* Deg. But according to Nuesebeck (1950), the correct specific name is *maculatus*.

Stock cultures of *Dermestes maculatus* (Deg.) were maintained on "Dog biscuits" at a temperature range of 75-80° F. Larvæ were isolated in glass dishes and small vials with appropriate media. Series of twenty-four larvæ were used in each test diet. Observations were made on alternate dates. Records were kept on pupation, emergence, larval time in days, number of instars, pupal period in days, weight of males and females in mg. in relation to different food media. For obtaining the desired levels of moisture in the food media, the oven-drying method was used. The dietary materials included in the experiment were casein hydrolysates (untreated and vitamin-free), amino acids (cystein, glutanic acid, tryptophane, glycine and arginine), fats (linoleic acid and cholesterol), carbohydrate (sucrose and corn starch) and salt (sodium chloride). These food factors were used as supplements to casein diet. Each test diet was replicated twenty-four times. The diets were changed on alternate days. Methods described by Fraenkel and Blewett (1943, 1954) were used to study the growth factors associated with yeast fraction (soluble and insoluble in water) in the casein diet. The "dog biscuit" is a mixture of meat, dried skimmed milk, wheat germ, dried beet, soybean meal, dehydrated cheese, molasses, and vitamin B complex, A and D. The materials were purchased from the Nutrition Biochemical Corporation, Cleaveland, Ohio.

RESULTS

Studies on the correlation between moisture levels of dietary media and the larval growth of *Dermestes maculatus* were carried out. Four levels of moisture (10%, 30%, 50% and 70%) were considered in the experiment. The "dog biscuit" which was reported as complete food was used as test diet. Twenty-four larvæ were used under each diet test. No larval growth was recorded at the 10% moisture level. Thirty per cent. moisture seems to be better than 50% or 70% for the larval growth. The higher the moisture content of the food media, the shorter was the duration of the larval period, and the greater was the weight of the female. The number of females surviving under condition of low moisture was greater than the number of males. Conversely, ratio of males to females was greater under condition of higher moisture. It was found that optimum moisture content of the "dog biscuit" food media was around 30%.

The larvæ of *Dermestes maculatus* were able to synthesize necessary sugar from casein in the presence of cholesterol for their growth. Both corn-starch or sucrose as supplements to casein were found to be unsatisfactory without cholesterol. This agrees with the reports of Fraenkel and Blewett (1943).

The amino acids (tryptophane, glycine, glutanic acid) as supplements to casein were as efficient as yeast. A study of B complex vitamins as supplements to vitamin-free casein indicated that thiamine, riboflavin, niacin, pentothenic acid, pyridoxine and choline were essential. Folic acid and biotin accelerated the larval growth and development.

Curiously enough, vitamin-free casein supplemented with sucrose, glutanic acid, glycine, tryptophane, cholesterol, salt and water, supported larval growth of the hide beetle. Probably the micro-organisms present in the intestine were able to synthesize necessary vitamins from the diet.

A diet consisting of casein, cholesterol and water was close to a minimum basic diet. Addition of sucrose, amino acid and salts gave very good larval growth. When yeast was substituted for amino acid in the basic diet, the larval growth was greatly accelerated, but there was practically no difference in the weight of adults. This indicates that both yeast and amino acid furnished similar growth factors. According to Fraenkel and Blewett (1942 and 1943), the yeast contains the vitamins, biotin and choline in addition to thiamine, riboflavin and niacin and other factors of vitamin B complex.

In literature it has not been demonstrated previously that the amino acids, such as tryptophane, glycine and glutanic acid, could be used for the formation of certain growth factors in insects. Further, by increasing the quantity of these three amino acids, the vitamin-free casein diet seems to provide a basic vitamin requirement of the beetle. The specific roles of micro-organisms present in the intestinal tract of the hide beetle which are able to synthesize

necessary vitamins from the basic diet need further investigation.

The writer expresses his gratitude to Dr. William E. Bickley and Dr. George S. Langford, Department of Entomology, University of Maryland, U.S.A., for their personal interest and invaluable guidance during the course of this investigation.

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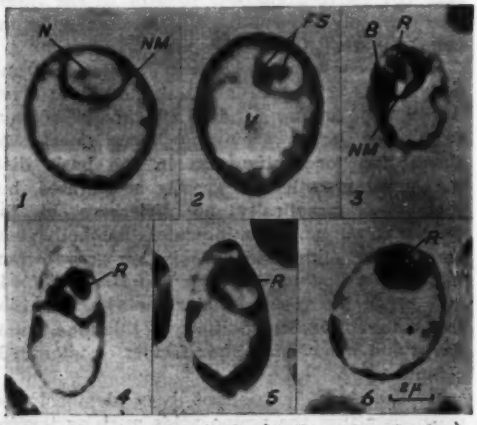
CHROMOCENTERS AND NUCLEOLAR EQUIVALENTS IN THE YEAST NUCLEUS

THE visibility of the nuclear and vacuolar membranes[1-3] in living cells from five-day wort (S.G. 1·020, pH 4·6-4·8) cultures of *Saccharomyces cerevisiæ* (NRR1. Y. 567) enabled the accurate location of the nucleus as an extra-vacuolar structure. Formed structures are often visible in the dormant living nucleus (Photos 1 and 2). They often lie apposed to the nuclear membrane giving it an irregularly thickened appearance (Photo 2). Though Heidenhain's hæmatoxylin yields superposable pictures on those of living nuclei[4-6] separation of the intranuclear organelles into distinct categories would be possible only by differential staining.



PHOTOS 1 and 2. Living cells (Ordinary Illumination). PHOTO 2. An intranuclear structure is lying in contact with the nuclear membrane.

PHOTOS 3 and 4. Iodine-formaldehyde acetic—Giemsa. PHOTOS 5 and 6. Modified Carnoy—Giemsa.

PHOTOS 3-6. The intranuclear structures could be distinguished into the blue (*B*) nucleolar equivalents and the red (*R*) chromocenters.

B., Blue nucleolar equivalents, *FS.*, Intranuclear structures; *N*, Nucleus; *NM*, Nuclear membrane; *R*, Red chromocenter; *V.*, Vacuole.

Feulgen preparations showed that the intranuclear structures were of two types.[4] Some were stained by leuco basic fuchsin while the others had an affinity for the counterstain, light green. When hydrolysed material was stained with Giemsa, the Feulgen positive areas were purplish-red while the Feulgen negative structures were light pink. An attempt was, therefore, made to discover whether these two types of organelles could be stained differentially with Giemsa in unhydrolysed cells.

Smears of cells with visible nuclei were fixed in iodine-formaldehyde-acetic acid solution[2,4] as well as in Carnoy's fluid as modified by Lindegren *et al.*[7] The slides freed of traces of the fixatives were rinsed well in a 1 : 1 mixture of tap- and distilled-water and transferred to a staining bath prepared by diluting 4 ml. of Giemsa (Gurr) with 20 ml. each of tap- and distilled-water.

When examined after an hour the cells appeared uniformly blue. The vacuole was unstained and in a few of the cells the chromatin was stained red. When the smears were carefully differentiated in 20% alcohol and examined as water mounts the cytoplasm and the nuclear membrane were blue. The intranuclear structures could be clearly separated into (1) the red-stained chromocenters (R. Photos 3-6), and (2) the blue-stained (B. Photos 3-6) nucleolar equivalents. The staining was similar whether the cells were fixed in iodine-formaldehyde-acetic (Photos 3 and 4) or in the modified Carnoy (Photos 5 and 6). The red chromatinic (Feulgen-positive) areas were less resistant to destaining than the blue-stained (Feulgen-negative) regions. This feature was more pronounced in cells fixed in Carnoy.

The intranuclear blue-stained areas show a wide variety of arrangement. They may be one (Photo 4) or more masses (Photos 3 and 6) or only an uneven lining to the nuclear membrane (Photo 5). The red-stained chromocenters usually lie free inside the nucleus (Photos 3-6). The demonstration of a nuclear membrane and differentially stained areas inside the nucleus in cells processed according to Lindegren *et al.*[7] (Photos 5 and 6) invalidates their

suggestion that the organelle is only the "spindle with chromatin" and not the nucleus.

Since the nucleolus of *Allium*[8] is of the same colour as the cytoplasm in Giemsa preparations, it would appear that the blue-tinted structures within the yeast nucleus (B. Photos 3-6) may correspond to the nucleolar substance of higher organisms. The yeast nucleus thus assumes a conventional structure not only in its possession of a nuclear membrane and chromocenters but also in having nucleolar equivalents.

I am very grateful to Dr. M. K. Subramaniam for his guidance and encouragement.

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THE EFFECT OF CORTISONE ON THE DISTRIBUTION AND CONCENTRATION OF ALKALINE PHOSPHATASE IN THE UROPYGIAL GLAND OF MALE PIGEONS

Sex hormonal regulation of the uropygial gland has been adequately demonstrated by Selye[1] and Kar.[2,3] However, the action of any extragonadal steroid on this sebaceous type of gland has not hitherto been reported and in view of this it seemed desirable to study the effect of cortisone, particularly on the cytochemical concentration of alkaline phosphatase in the uropygial gland of pigeons.

Twelve adult male pigeons were used in this study of which 6 were injected intramuscularly with cortisone acetate ("Cortogen" Schering, U.S.A.; 4 mg. daily for 7 days) and the remaining 6 were left uninjected to serve as controls. Autopsy followed 24 hours after the final injections. The uropygial glands were carefully dissected out, weighed to the nearest milligramme and fixed appropriately for histological studies. Technique of Gomori[4] was used for demonstration of alkaline phosphatase.

Gross examinations at autopsy revealed consistent hypertrophy of the uropygial glands of the experimental pigeons (Table I). Histological study also disclosed a pronounced stimulation of this organ in cortisone-treated birds. This was exhibited by an accelerated development of the alveolar system. The lumen of majority of the alveoli were filled up with sebaceous secretion and a pronounced hyperemia was also indicated in the alveolar septa. It might be recalled in this connection that contrary to the present findings, cortisone exerted practically no influence on the mammalian sebaceous glands.[5]

Table I

Summary of the weight of the uropygial glands

	Weight of uropygial gland		Body weight at autopsy (gm.)
	Absolute (mg.)	Relative‡ (per cent.)	
Uninjected Controls (*6*)*	52±3·97†	0·0205	251·83±3·90
Cortisone treated (*6*)	86·5±4·39	0·0358	241·11±4·01

* Figure in parenthesis indicate the number of animals.
† Standard error of the mean.
‡ Uropygial gland weight as percentage of the body-weight.

In agreement with the findings of Kar[6] we observed that in general, the enzyme was distributed in a diffuse manner in the gland of the normal birds. The connective tissue surrounding the alveoli showed slight reaction. The endothelium of the stromal blood vessels and the fibroblast cells exhibited a moderate enzymatic activity. Appreciable phosphatase activity was evident in the "indifferent" as well as cuboidal cells bordering the alveolar wall. The nucleus of the cells adjacent to the cuboidal epithelium showed moderate reaction, but the enzyme was totally absent from the cytoplasm of the cells. Almost negative reactions were encountered in the rest of the alveolar epithelium. Moderate phosphatase activity was evident in the luminal epithelium of the duct.

Cortisone treatment caused an augmentation in phosphatase activity. This was particularly noticeable in the basal cuboidal cells of the alveolus. The enzyme appeared to be almost uniformly distributed in the nucleus and in the cytoplasm of the cells. Cytoplasmic granules present in the alveolar epithelium also showed

a prominent reaction for alkaline phosphatase. The nuclear phosphatase activity, however, remained practically unaffected in the hormone-treated pigeons. In the stromal blood vessels the enzyme was restricted to the endothelium. The secretory substance in the alveolar lumen also showed a slight reaction for this enzyme. However, a remarkable mobilization of alkaline phosphatase was noticed in the duct epithelia.

The results obtained in the present experiment demonstrate that alkaline phosphatase activity is enhanced in the uropygial gland of the pigeon after cortisone treatment. It is suggested that in the cortisone-treated birds, a physiological relationship exists between the hypertrophy of the uropygial gland and the increase in phosphatase activity as this enzyme is known to play an important role in the lipid metabolism of the holocrine glands.[7]

Histophysiology Laboratory, Dept. of Zoology, University of Calcutta, Calcutta-19, *June* 20, 1958.

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A NOTE ON APHIDS OF CALCUTTA AND SUBURBS WITH SPECIAL REFERENCE TO THE NEWLY RECORDED HOST PLANT FAMILIES FOR SOME OF THE SPECIES

Till 1955, twenty-six species of aphids had been known to occur in West Bengal as plant pests. But the present investigation leads to the fact that there are twenty-seven species of aphids, including *Rhophalosiphum nymphææ* L. which is for the first time recorded from West Bengal. Besides, for some of the known species, a few plant families are also recorded new, *e.g.*,

Aphis craccivora Koch.: Cucurbitaceæ, Labiatæ, Nyctaginaceæ, Scitaminaceæ and Urticaceæ. *Aphis gossypii* Glover: Amarantaceæ, Araliaceæ. *Liphaphis erysimi* (Kalt.): Araliaceæ, Cruciferæ. *Myzus persicæ* (Sulz.): Acanthaceæ, Malvaceæ. *Rhophalosiphum nymphææ* L.: Cactaceæ, Leguminosæ. *Rhophalosiphum rufiabdominalis* (Sasaki): Araceæ. *Tetraneura hirsuta* Baker: Cruciferæ, Solanaceæ.

The authors are indebted to Dr. J. P. Doncaster of British Museum, London, for identifying a part of collections which helped them to have materials for comparison, and to Prof. A. Dasgupta, formerly Head of the Department of Botany, Bangabasi College, Calcutta, for kindly identifying the plant families.

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Zoology Laboratory, St. Xavier's College, Calcutta-16, *June* 24, 1958.

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HOMOLOGY OF THE PAPPUS IN THE LIGHT OF TRICHOME DISTRIBUTION

Homology of the pappus, as stated by Koch,[2] is still open to question. It represents a modified calyx according to the phyllome theory which was supported by Cassini, Bentham, Worsdell, Hutchinson, etc. (*cf.* Small[6] for a review of the relevant literature). This view is also adopted by systematists in general as stated by Lawrence.[4] Pappus is a homologue of the trichomes or emergences according to the trichome theory which was advanced by Warming, Masters,[6] etc. This was upheld and greatly strengthened afterwards by Small[6] who studied the pappus of a large number of species and who particularly took into account its anatomical structure. The same view was followed later by Koch[3] who considered the problem in the light of the vascular anatomy of the ray flowers of some of the Helianthæ.

Recently, pappus of *Helianthus annuus* L. and *Vicoa indica* DC. was interpreted as phyllomic in origin by the first author[5] on the basis of altogether a new evidence, *viz.*, the relative distribution of sclerenchyma among the floral organs. In this note, evidence from yet another aspect is recorded which indicates that pappus originated from the calyx in some more members of the Compositæ. There are several species of the family in which the pappus parts have been observed to bear trichomes which are otherwise characteristic of the vegetative

parts and other floral organs like the bracts, paleæ, corollá, ovary, etc. Similar to the latter organs the pappus parts too have an epidermal layer and the trichomes observed are differentiated from single epidermal initials as for example seen in *Adenostemma lavenia* O. Kze. (Figs. 5, 6 and 7). First the trichome initial

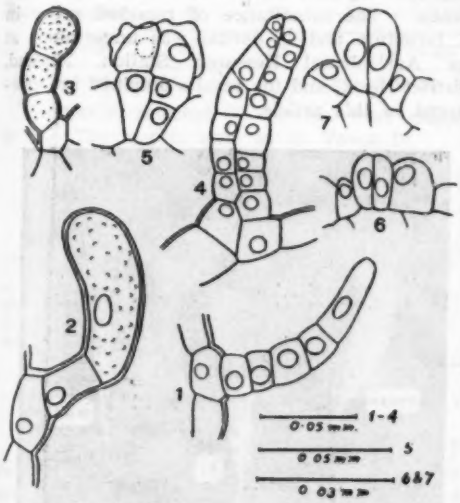

FIG. 1. Rostrate filiform hair, *Parthenium argentatum.*
FIG. 2. Cylindrical hair, *Parthenium argentatum.*
FIG. 3. Cylindrical hair, *Parthenium hysterophorus.*
FIG. 4. Biseriate gladular hair, *Eriophyllum stachadifolium.*
FIG. 5. Biseriate vesicular glandular hair, *Adenostemma lavenia.*
FIG. 6. Two-celled stage of biseriate vesicular glandular hair, *Adenostemma lavenia.*
FIG. 7. Two-celled stage with the dyads enlarged, *Adenostemma lavenia.*

divides anticlinally and gives rise to two juxtaposed daughter-cells (Fig. 6). These cells later become very much enlarged in their size (Fig. 7). Further differentiation involves one to two periclinal divisions of each of the dyads followed by detachment of the cuticle from the end cells into a vesicle (Fig. 5). Trichomes may be limited in their distribution to the lateral surface of the pappus parts (*e.g., Cæsulia axillaris* Roxb.) or also occur upon the tips of the latter (*e.g., Adenostemma lavenia,* Fig. 8). They are usually a few in number but denser in *Adenostemma lavenia.* The composites noted are as in Table I.

In the species listed above, it is obvious that the pappus parts cannot be regarded as hairy-structures as explained according to the trichome theory, because it will amount to occurrence of trichomes upon trichomes which is quite an improbable phenomenon. It is important to note that the pappus parts and the trichomes borne by them are quite dissimilar in their structure as for example may be observed in *Adenostemma lavenia* (Fig. 8). The former are relatively massive structures and consist

FIG. 8. Pappus part with hairy epidermis, *Adenostemma lavenia,* × 410.

TABLE I

S. No.	Name of the species	No. of parts of the pappus	Trichome types* present on the pappus
1	2	3	4
1	*Adenostemma lavenea* O., Kze.	3–4	Biseriate vesicular glandular hair
2	*Parthenium hysterophorus* L.	2	Rostrate filiform hair and cylindrical hair
3	*Parthenium argentatum* Gray	3	do.
4	*Parthenium incanum* H. B. K.	3	do.
5	*Parthenium alpinum* (Nutt.) T. & G.	2–3	do.
6	*Eriophyllum stachadifolium* Lag.	6–9	Biseriate glandular hair

* The names of the trichomes are adopted from the thesis to be submitted shortly by the first author.

of, apart from the hairy epidermis, ground tissue and a vascular strand. Thus, in possessing the three fundamental tissues the pappus parts structurally resemble any other reproductive

phyllome[1] such as the petal, stamen or carpel, and this homology itself is another evidence of their phyllome or calyx origin. Further, they are also less in number being usually not more than five in each of the species as is evident from the above list.

It is of significance that the species were recorded after examining more than a hundred species (representing all the thirteen types of the family) in which many have the common plumose pappus consisting of numerous hair-like structures, called the setæ.[6] Since trichomes are not borne by the setæ, therefore, their possession by the pappus parts which are massive in size and less in number as noted in the present species, is probably not without significance. In terms of the phyllome theory, the pappus of these species can be regarded to represent a primitive type since in size, structure, and number of its parts it resembles a typical five-merous calyx such as hypothesized by Koch[3] to have been borne by the earliest Compositæ. The setose pappus, therefore, represents a specialised form which probably evolved later by dismemberment of the primitive type into numerous parts. Evolution of this might have obviously involved origin and selection of such mutations which had brought about a division of the normal sepal primodia into numerous bits as are now witnessed in the development of the plumose pappus of, for example, *Tridax procumbens* Linn.[2]

The authors are grateful to Prof. R. C. Rollins, Gray Herbarium, Harvard University, Cambridge, and Dr. B. L. Hammond, Salinas, California, for sparing the material of *Parthenium* spp.

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INHERITANCE STUDY IN WHEAT

A LARGE number of studies have been made to determine the mode of inheritance of typical characters of the various wheat species. The genus *Triticum* has at present twenty total number of species and subspecies.[2] *T. durum* and *T. turgidum* both have $n = 14$ chromosomes. The inheritance of ramified spike in *T. turgidum* and *T. durum* was undertaken at the Agricultural Research Station, Niphad, District Nasik, and the results obtained are presented in this article.

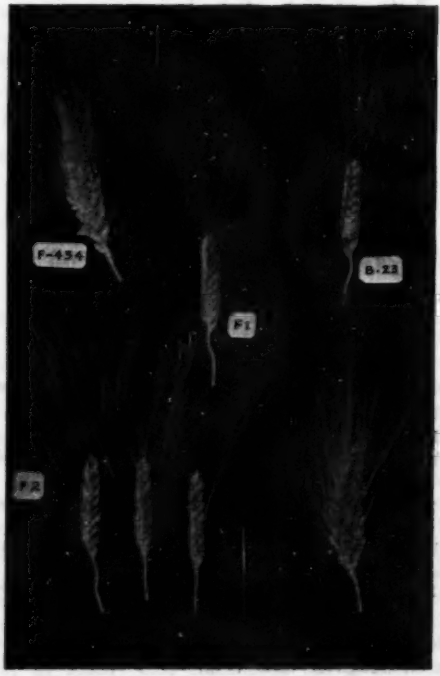

FIG. 1

Many workers[3–5] have studied the behaviour of the ramified spike (branched ear) and the effect of day length and temperature on the expression of it.

F. 434, a type with ramified spike belonging to *T. turgidum* introduced from Egypt, was crossed with an improved type Baxi 23,[1] a *T. durum* with simple spike in the year 1952-53 and studied in the subsequent years. The F_1 was normal, *i.e.*, unbranched spike, was dominant to branched spike. The fertility of the segregates was normal. The F_2 observations are presented in Table I and in Fig. 1.

TABLE I

F_2 segregation in the cross F. 434 × Baxi 23

Phenotypes	Observed (O)	Expected (C)	O—C	$(O—C)^2/C$
Simple spike ..	280	279	+1	0·00358
Ramified spike ..	92	93	−1	0·01075
Total ..	372	372	—	0·01433
P : 0·90 to 0·95			X^2 : 0·01433	

Randomly selected 54 families were studied in F_3. The results were as in TABLE II.

TABLE II

Behaviour of families (segregates) in F_3

Phenotypes of families	Observed (O)	Expected (C)	O—C	$(O—C)^2/C$
Simple ..	21	13·5	+7·5	4·16
Segregating ..	22	27·0	−5·0	0·92
Ramified ..	11	13·5	−2·5	0·46
Total ..	54	54·0	0·0	5·54
P : 0·05 to 0·1			X^2 : 5·54	

The goodness of fit test of the F_2 and F_3 results proved that segregation of the character ramified spike is monogenic, giving 3 simple (unbranched) to 1 ramified spike plants.

In the study of the inheritance of ramified spike in *T. turgidum* and *T. durum* at the Agricultural Research Station, Niphad, the results obtained are as below.

F_1 plants were with simple spikes, *i.e.*, ramified spike is recessive. The segregation in F_2 was 3 simple to 1 ramified. The segregation of 54 families of F_3 was in the ratio of one homozygous simple spike; two heterozygous simple; and one homozygous ramified spike. The results confirmed the findings of Tschermak.[5]

I am grateful to Prof. V. M. Chavan, for his encouragement during the study, and Dr. S. Soloman, for going through the manuscript and giving valuable suggestions. Thanks are due to Sarvashri Y. N. Shaikh and M. G. Tamboli for their help in the fieldwork during the course of the present investigation.

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NOTE ON ALTERNATE HOST PLANTS OF *CHILO ZONELLUS* SWINHOE

Chilo zonellus Swinhœ is a major pest of Sorghums and maize and occasionally of sugarcane and is widely distributed all over India. During the investigation carried out at the College of Agriculture, Poona, Trehan and Butani[1] recorded this pest to breed also in Sudan grass (*Sorghum vulgare* var. *sudanense* Stapf.), *Nachini* (*Eleusine coracana* Gaertn.), *Baru*—Johnson grass (*Sorghum halepense* Pers.), Job's tears (*Coix lachryma-jobi* L.) and *Kawdia* (*Polytoca barbata* Stapf.), etc. These grasses, growing wild in various fields, on the pastures and along the bunds and water channels were found to harbour the pest during the off-season. Similarly, voluntary *jowar* plants that germinated from the scattered seeds in the fields and farmyards, etc., also afforded most suitable host plants for the pest to flourish. A good many 'dead hearts' were collected from these alternate hosts. A detailed study revealed that the maximum infestation was during the month of July, when the average infestation recorded was 45·2%, 48·4%, 48·7% and 51·0% in *P. barbata*, *Andropogon sorghum*, *A. halepense* and *S. sudanense* respectively.

The observation recorded suggested that the wild grasses and the voluntary *jowar* plants definitely serve as breeding places for *Chilo zonellus* as they afford most suitable facilities for the moths, to lay their eggs on these plants, where they hatch out and feed on them till the new crop comes up. To avoid the carry-over of the pest it is necessary to eliminate the availability of these alternate hosts, for which clean cultivation is advocated.

Sincere thanks are due to Dr. K. N. Trehan, under whose able guidance this work was conducted at the College of Agriculture, Poona.

Pusa, Bihar, DHAMO K. BUTANI.
August 17, 1957.

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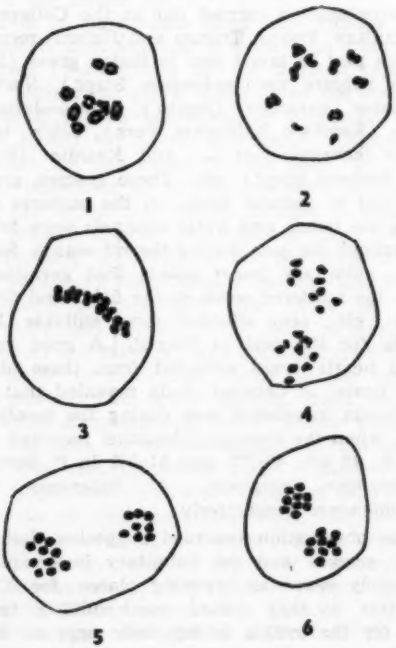
CHROMOSOME NUMBER IN *IBERIS UMBELLATA* L.

EXCEPTING the conflicting reports on chromosome number[1,2] no other cytological work has been done in *Iberis umbellata* L. This note deals with the meiotic behaviour of chromosomes in the species and a discussion of its probable chromosome number. Majority of pollen mother-cells at diakinesis and metaphase I had

nine bivalents (Figs. 1 and 3); a few, however, showed eight bivalents and two univalents (Fig. 2). The distribution of chromosomes at



FIGS. 1–6 (× 1,700). Meiotic stages. Figs. 1–2. Diakinesis. Fig. 1. Nine bivalents. Fig. 2. Eight bivalents and two univalents. Fig. 3. Metaphase I, showing nine bivalents. Figs. 4–5. Anaphase I. Fig. 4. Nine chromosomes at either pole. Fig. 5. Showing 8 + 10 distribution of chromosomes. Fig. 6. Metaphase II showing nine chromosomes in each group.

anaphase I was quite regular, nine chromosomes being clearly seen at either pole (Fig. 4). A few of the pollen mother-cells, however, showed an unequal distribution of chromosomes, eight going to one pole and ten to the other (Fig. 5). Nine chromosomes were included in each group at metaphase II (Fig. 6). Manton[2] working with the somatic nuclei of *I. umbellata*, reported fourteen as its diploid chromosome number. Thomas,[1] however, found $2n = 16$. Our observations indicate that the haploid chromosome number in this plant is nine ($2n = 18$). *I. umbellata* thus shows three types with reference to its chromosome number.

We are thankful to Prof. P. Maheshwari, Head of the Department of Botany, University of Delhi, for the facilities and encouragement.

Dept. of Botany, University of Delhi, Delhi-8, *May* 5, 1958.

P. N. BALI.*
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* Lecturer in Botany, Hansraj College, University of Delhi, Delhi 8.

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CHROMOSOME NUMBER IN *CHLOROPHYTUM TUBEROSUM*, BAKER

THERE are more than 50 species in the genus *Chlorophytum*, Ker. distributed in the tropics of both hemispheres.[1] Till now, the chromosome number has been worked out only in 10 species, and *C. tuberosum* has not been included in the list.[2] Therefore, the authors presume that the haploid chromosome number ($n = 8$) determined for *C. tuberosum*, to have been reported here, for the first time.

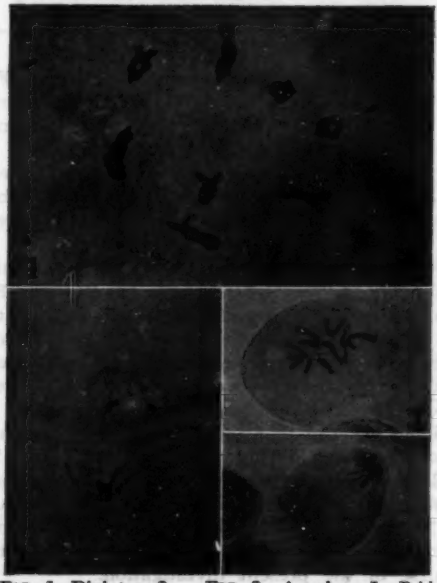

FIG. 1. Diplotene 8_{II}. FIG. 2. Anaphase-I. Bridge with fragment. FIG. 3. Pollen mitosis N = 8. FIG. 4. Pollen mitosis anaphase. All photomicrographs at magnification, × 1,000 *ca.*

C. tuberosum is found in abundance growing as a weed during early monsoon in Poona. It is reported that *C. tuberosum* is also sometimes cultivated in gardens as its tender leaves are used as 'Pot herbs' and its flowers as ornamentals, kept in vases. It is a short-lived, small herb with tuberous roots. The leaves are

TABLE I

Chiasma frequency at diplotene in C. tuberosum

No. of P.M.C.'s examined	Chaismata					
	Total for 50 P.M.C.'s		Per cell		Per each bivalent	
	Interstitial	Terminal	Interstitial	Terminal	Interstitial	Terminal
50	780	370	15·6	7·4	1·3	1·4
					1·4	1·3
Total ..	1150		23·0		1·3	0·0
					1·2	1·1
					2·2	1·3
					3·0	1·1
					3·1	1·2
					2·1	0·0

sessile, radiate, falcate, recurved and wavy. The plant bears white flowers during July-August. Although the plant soon dies off, during the next monsoon, the underground tubers once again sprout up.

Chromosome number was determined by meiotic studies. For this purpose, flower-buds were fixed in Carnoy's (6 : 3 : 1) and permanent Feulgen and Propiono-carmine squashes were prepared. At diplotene (Fig. 1), diakinesis and metaphase-I of meiosis in microsporocytes, there were 8 bivalents. The chiasma frequency per bivalent observed is presented in Table I.

At anaphase I (Fig. 2), 0·12% abnormality in the form of inversion bridges with fragments were noticed. Pollen mitosis (Fig. 3) also revealed the haploid number to be 8, in *C. tuberosum*. Anaphase of pollen mitosis (Fig. 4) was, however, normal.

The presence of inversion bridges indicates structural hybridity of the *C. tuberosum* species. Sheriff (1957)[4] reports spontaneous chromosome inversions in *C. elatum*, R.Br. The genetic role of inversions in evolution has been well brought out by Dobzhansky (1955).[3]

A critical study on the cytological behaviour in the genus *Chlorophytum* where spontaneous inversion hybrids are suspected, has been now undertaken.

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A PRELIMINARY STUDY OF COLCHICINE-INDUCED POLYPLOIDS OF *ALYSSUM MARITIMUM* LAM.

THE authors have recently published work done on Colchicine-induced tetraploidy in *Iberis amara* L. and *Linaria vulgaris*.[1-3,7,8] This paper deals with a similar type of work on *Alyssum maritimum* (Sweet Alyssum) which is an important winter annual garden plant.

The apical growing points of 46-days old seedlings having 8 leaves on an average, were covered with small cotton wads which were kept moist with aqueous colchicine solution. The treatments employed were 0·05, 0·10 and 0·20% colchicine solution for 6 and 12 hr. Ten plants were used for each treatment. The most successful treatment was found to be 0·20% colchicine solution applied for 6 hr. The leaves which came out after the treatment were longer, broader, thicker, more rough and deep green in colour as compared to those of the control. The average thickness of leaves in the control and the polyploid was 327·25 μ and 500·50 μ respectively. The deep green colour of the leaves in the polyploid plants was found to be due to the presence of more numerous and larger chloroplasts. The epidermal hairs, epidermal cells, stomata, cells of the palisade and spongy parenchyma of leaves in the polyploids were larger than those of the control. The guard cells of the stomata of the untreated plants average 21·28 μ in length and 5·47 μ in width as compared with an average length and width of 44·59 μ and 11·75 μ respectively in the polyploids. The number of stomata per sq. mm. in the control and polyploid was 221·68 and 83·13 respectively.

Flowering was delayed and extended in the polyploid plants. The polyploids had conspicuously large flowers. The pedicel, sepals, petals, stamens, pistil, ovules, fruit, seed and embryo

of the polyploid plants showed a general enlargement over their counterparts in the control. It may, however, be mentioned that a few of the polyploid plants showed a reduction in flower size. The percentage of pollen fertility in the polyploid plants was rather low, the averages for the control and the polyploid being 95·58% and 76·06% respectively. The fertile pollen grains of the polyploids were larger than those of the control, the average diameter of the pollen grains of the polyploid and the control being 39·52 μ and 21·68 μ respectively. Fruit and seed-setting in the polyploids was extremely poor but this handicap could possibly be overcome by leaving a larger number of plants for seed collection.

The colchicine-treated plants were cytologically analysed. Squashes of pollen mother-cells were stained with aceto-orcein. The meiotic chromosome numbers of the control plants and the polyploids were determined as 12 and 24 respectively. It is worthwhile to mention here that taking the genus *Alyssum* as a whole, the naturally occurring *A. maritimum* is at a triploid level.[5,6] The artificially induced polyploids would thus represent a hexaploid condition. The control plants showed 12 bivalents at diakinesis and metaphase I. The distribution of chromosomes at anaphase I was mostly regular in the control plants, 12 chromosomes going to either pole. The details of meiosis in the naturally occurring triploid *A. maritimum* have been reported elsewhere.[4] Many of the possible configurations showing varying numbers of quadrivalents, bivalents and univalents were seen in the preparations of the polyploid plants. Twelve quadrivalents were also seen at diakinesis. In some of the pollen mother-cells the distribution of chromosomes was quite regular but in many of them a few chromosomes were seen to lag behind resulting in the unequal distribution of chromosomes. In a few pollen mother-cells anaphasic bridges were also observed. The wall formation in the control and polyploid was of the simultaneous type. Formation of varying numbers of multivalents, lagging chromosomes at anaphase, and formation of chromosome bridges, etc., may be the probable causes for low pollen fertility and consequently poor fruit and seed-setting in the polyploids.

We are thankful to Prof. P. Maheshwari, Head of the Department of Botany, University of Delhi, for the facilities and encouragement.

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IODINE CONTENT OF SOME INDIAN FODDER PLANTS

ACCORDING to Underwood,[4] subnormal levels of iodine in soils and hence in foods and waters of certain parts of the world can be correlated with the incidence of goitre in humans and animals. However, there is no data on the iodine content of Indian plants and foods except Lander's[2] who found that goitre was notoriously prevalent in Kashmir and some of the districts of the Himalayan foot-hills in the Punjab and that the iodine content of fodder plants from Kangra and Murree were far lower than those of the plains.

The iodine content of pasture plants, though of no significance to the plants themselves are of profound importance to the animals dependent upon them. A preliminary survey of the iodine status of the grassland soils of Western India revealed that the total iodine content was negligible, varying from 0·00 to 0·91 p.p.m. Therefore, the iodine content of some important fodder plants was determined by the method of Houston[1] and the minimum, maximum and the mean contents of iodine in 22 species are reported in Table I.

Table I shows that the fodder plants of Western India contain very low amounts of iodine. The maximum iodine content was 0·076 p.p.m. in a sample of *Dicanthium annulatum* and the minimum was 0·002 p.p.m. in *Pseudenthistiria heteroclita*. The range in the average iodine content of the samples was from 0·006 to 0·048 p.p.m. A few common weeds of the grasslands (samples 19 to 22) which were also analysed for their iodine content did not appear to contain any significant amounts. The outstanding feature of the data are the wide variations in the iodine content of the same species as well as of different species growing in the same locality and soil type.

Russel[3] has shown that New Zealand pastures contain from 0·024 to 0·072 p.p.m. iodine

TABLE I
Iodine content of some fodder plants and weeds
(in p.p.m. of dry matter)

No.	Name of Species		Min.	Max.	Mean	No of samples analysed
1	*Pseudenthistiria heteroclita* Hk.	..	0·002	0·034	0·021	6
2	*Themeda triandra* Forsk.	..	0·008	0·023	0·018	10
3	*Themeda tremula* Hk.	..	0·001	0·009	0·006	5
4	*Licanthium annulatum* Stapf.	..	0·012	0·076	0·045	8
5	*Ischæmum ciliare* Retz.	..	0·010	0·039	0·026	6
6	*Cymbopogon martini* Stapf.	..	0·006	0·047	0·017	4
7	*Eulalia fimbriata* Bl. & Mc.	..	0·009	0·027	0·014	5
8	*Arthraxon meeboldii* Stapf.	..	0·011	0·040	0·022	6
9	*Heteropogon contortus* Beauv.	..	0·024	0·068	0·046	10
10	*Arundinella tenella* Lawli.	..	0·010	0·054	0·023	4
11	*Spodiopogon albidus* Benth.	..	0·014	0·043	0·029	4
12	*Indigofera tinctoria* Linn.	..	0·023	0·040	0·035	6
13	*Crotolaria triquetra* Dalz.	..	0·011	0·031	0·020	4
14	*Heylandia latebrosa* DC.	..	0·004	0·010	0·006	8
15	*Crotolaria linifolia* Linn.	..	0·009	0·027	0·018	4
16	*Alysicarpus vaginalis* DC.	..	0·021	0·053	0·038	6
17	*Smithia sensitiva* Ait.	..	0·008	0·026	0·012	5
18	*Zornia diphylla* Pers.	..	0·026	0·049	0·032	6
19	*Glossocardia linearifolia* Cav.	..	0·014	0·030	0·015	6
20	*Borreria stricta* Schum.	..	0·005	0·016	0·006	4
21	*Lindernia ciliata* Linn.	..	0·021	0·036	0·024	4
22	*Vicoa indica* DC.	..	0·041	0·052	0·048	4

whereas English pastures contain from 0·21 to 0·84 p.p.m. Lander's values for the iodine content of the Punjab grasses appears to be rather high, varying from 0·118 to 0·902 p.p.m. The fodder hays from the goitre areas of Murree and Kangra, contain according to him, from 0·118 to 0·380 p.p.m. iodine. Probably these samples were contaminated. As compared to Lander's values, the fodder plants of Western India appear to be very poor in their iodine content. However, it was beyond the scope of this investigator to study whether goitre is prevalent in the area. A co-ordinated approach by the Veterinary and Agricultural Departments may yield interesting results.

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Institute of Science,
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A SHORT NOTE ON SOME OF THE INDIAN SOLANUM SPECIES

NEARLY 20 Solanum species grow wild in India and some investigations have been carried out on many of these. However, *Solanum indicum*, *S. luteum* and *S. verbascifolium*, growing wild in Northern India, have not so far been properly investigated and nothing is known regarding the nature of alkaloids, present in them. A systematic study of the berries of these species was therefore carried out.

Coarsely powdered dry berries were extracted with alcohol in a sauxhlet. The solvent was removed and the alkaloid extracted with 5% acetic acid. The fatty matter and other extraneous impurities were removed by shaking the aqueous solution with petroleum ether and benzene, after which the gluco-alkaloid was precipitated with ammonia. It was repeatedly crystallised from alcohol.

The gluco-alkaloid was subsequently hydrolysed with 5% hydrochloric acid, decomposed with ammonia and crystallised from alcohol. The alkaloid obtained was further characterised by preparing its acetyl derivative. The results of our observations are given in Table I.

Mixed melting points with gluco-alkaloid solasonine and alkaloid solasodine, isolated from *S. xanthocarpum*, were taken and no depression was observed. When alcoholic solution of the alkaloid was treated with sulphuric acid, a green fluorescence, characteristic of solasodine, was produced. The alkaloid also gave characteristic colour reaction with anisaldehyde and hydrochloric acid.

TABLE I

	Solanum indicum	*S. verbascifolium*	*S. luteum*
Gluco-alkaloid ..	Softened at 192°; m p. 275–78° (decomp.)	Swells at 190°; m.p. 276–78° (decomp.)	Softened at 228°; m.p. 273–75° (decomp.)
Alkaloid hydrochloride ..	m.p 308–10°	m.p. 304–05°	m.p. 305–08°
Alkaloid ..	m.p. 201–02°	m.p. 201–02°	m p 201–02°
Acetate of alkaloid ..	m p. 191–93°	m.p. 191–92°	m.p. 189–91°

A perusal of the above shows that all the above solanum species contain the gluco-alkaloid solasonine, which on hydrolysis with 5% hydrochloric acid yields the alkaloid solasodine.

Regional Res. Lab., Jammu, *June* 10, 1958.

S. S. CHAUDHARY.
VISHWA PAUL.
K. L. HANDA.

OCCURRENCE OF *ISOETES* IN MADHYA PRADESH

THERE are about 65 species[1] of *Isœtes* but only four have been recorded in India. These are *I. coromandelina* L.,[2,3] *I. sahyadrii*,[4] *I. sampatkumarani*[5] and *I. dixitei*.[6] So far, none have been recorded from Madhya Pradesh, one of the largest States of India. The authors have observed a species of *Isœtes* growing abundantly at Omkareshwar and this note deals with the preliminary aspect of its occurrence.

Omkareshwar is a famous sacred place of Hindus, situated on the banks of River Narbada. Its height is 579·7' above sea-level and the climate is not much different from that of Indore.

One of us (Mr. Patel), while visiting this place on 9th October 1955, accidentally discovered *Isœtes* plants growing with grasses, in a slow-running temporary stream. Subsequent observations of this locality in different seasons, for about 3 years, clearly indicate that this plant has a definite growing season, which starts in mid-June, i.e., after the beginning of monsoon and continues till October. In addition to the short span of life, these plants are very much restricted in distribution, as it is clear from their absence in similar places within a radius of 7 miles.

The plants vary from 15·5 cm. to 40 cm. in height and are mostly bisporangiate with a definite order of arrangement of the sporophylls.

The species reported here differs from the previously described species and is in all probability a new one. However, further critical study is continued to ensure this.

Dept. of Botany, Holkar College, Indore, *April* 28, 1958.

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OCCURRENCE OF A GREEN JASSID—*EMPOASCA* SP.—ON *SESBANIA SPECIOSA* L.

AN instance of a heavy occurrence of a small green jassid belonging to the genus *Empoasca*, was noted for the first time on *Sesbania speciosa* L. during 1955 at the Agricultural Research Station, Aduthurai, where this green manure plant used to be raised as a pure crop, to a large extent, year after year, for the manuring of paddy. The pest flared up into sudden prominence on the crop during the month of September. Due to the sucking activity of the adults and nymphs of the insect, the leaves turned pale, shrivelled up and shed in large numbers. Attempts made towards the control of the pest revealed that D.D.T. 5% dust was quite effective. Application of the chemical by means of a rotary duster at the rate of about 20 lb. per acre secured an excellent extermination of the pest in the course of about 48 hours.

Subsequently, the insect was found invading the bitter gourd. The application of H.E.T.P. 0·1% spray was quite suitable as it secured an effective control of the pest and was at the same time free from any phytocidal action.

The author's thanks are due to the Head of the Division of Entomology, Indian Agricultural Research Institute, New Delhi, for kindly identifying the insect as *Empoasca* sp.

Agric. College and Res. Inst., Coimbatore, *June* 16, 1958.

E. V. ABRAHAM.

REVIEWS

Energetics in Biochemical Reactions. By Irving M. Klotz. (Academic Press, New York), 1957. Pp. xv + 502. Price $ 12.80.

The increasing tendency to interpret biological phenomena in terms of conceptions that have advanced our knowledge of simple chemical reactions leaves the average biologist bewildered. The thermodynamic approach in the usual run of monographs generally keeps them off. While one may expect from the title an approach of the Bronsted school, fortunately for the non-professional physical chemist the present monograph deals largely with the classical approach. The lucid treatment of thermodynamics by Professor Klotz in an earlier monograph leads one to expect a clear non-mathematical exposition, which can be readily followed by a non-mathematician and the reader will not be disappointed. The concepts of energy and of entropy are clearly presented with suitable examples (there may be difference of opinion in one or two instances) and the student is led on to free energy and its relation to concentration. The basic concept of group transfer, electrochemical relationships and a glimpse of molecular statistics follow in succeeding chapters. The book can be safely recommended to any biologist who desires to acquire a reading knowledge of the language of the physical chemist without the rigours of a mathematical approach used by the specialist. The book is well produced and free from misprints.

S. V. ANANTAKRISHNAN.

Guided Weapons. By E. Burgess, F.R.A.S. (Chapman & Hall, Ltd., London), 1957. Pp. 255. Price 25 *sh.*

It is impossible at the present time to write a really satisfactory book on guided weapons owing to the classified nature of much of the most interesting material. This book makes a very laudable attempt to present all the available information on current and past weapons in a form to suit the "intelligent layman".

The first four chapters deal with the principles on which missiles are designed and cover propulsion, guidance, control and testing procedures. The presentation is completely non-mathematical and draws its examples, as far as possible, from current equipments which are sometimes given in a degree of detail somewhat at variance with the general nature of the main argument.

The next three chapters deal with actual missiles, ground-to-air, air-to-air, air-to-ground and ground-to-ground, and the final chapter deals with production and development problems. The examples in this part of the text are almost wholly taken from German war-time projects and American current developments, the little information that is given on British weapons is largely a matter of conjecture.

The amount of available unclassified information varies considerably from weapon to weapon which makes it difficult for the author to preserve a uniform narrative style. The readability of this part of the book is further marred by quoting an unnecessary number of detailed mechanical dimensions, each of which is given both in inches and centimetres. Since these figures are repeated in tables at the end of each chapter, they could, with advantage, have been largely omitted from the script.

The general format of the book is good and the text is profusely illustrated with drawings and photographs, many of them of actual weapons in flight or on the launcher. Each chapter ends with an impressive list of references, mainly to magazine articles, and the book ends with a bibliography and a useful index.

C. H. S.

Atomic Radiation Dangers and What They Mean to You. By H. W. Heckstall-Smith. (J. M. Dent & Sons, Ltd., London, W.C. 2), 1958. Pp. xii + 106. Price 7 *sh.* 6 *d.*

This little monograph presents the effects of natural radiation, man-made, industrial, medical and similar radiations, as also A-Bomb, H-bomb and atomic plant radiation on us in an impartial manner. Publication of a book of this type is to be welcomed, particularly because nowadays observations on the effects of radiation do not reach us in an unbiassed form. The subject is of topical importance in view of the activities of the big powers concerning the manufacture and testing of atomic weapons. The author aims at presenting facts in a proper perspective—"facts of ignorance as well as facts of knowledge and at making them understandable by non-scientists".

The book is divided into eight chapters in the first two of which are given the necessary in-

troductory information regarding atomic radiation and their effect on living creatures. Then follow three chapters dealing respectively with natural radiation, man-caused radiation and nuclear explosions. The next two chapters are on the genetic danger and the cancer danger caused respectively by radiocæsium and radiostrontium. The last chapter is on hazards associated with nuclear reactors and the lessons one ought to learn from accidents like those which occurred at the Chalk River and Windscale.

The author has given the main facts without assuming any previous knowledge so that the book can be read and understood even by "ordinary readers" who are not men of science.

This is indeed a book which every thinking man ought to read and study and thereby assess the real situation regarding the dangers of atomic radiation and atomic tests in their proper perspective. Any one who reads the book even in a cursory way will at once realise two important things. One is that there is perhaps a shortage of high level scientific men compared to the high level responsible work which has to be carried on. The other is that unbiassed knowledge about the hazards associated with atomic energy is not sufficiently widespread.

S. RAMA SWAMY.

Film Formation, Film Properties, and Film Deterioration. By Charles R. Bragdon (Technical Editor). (Published by Interscience Publishers, Inc., New York), 1958. Pp. 422. Price $ 9.75.

This publication typifies how a group of energetic men interested in paints and varnishes can make a positive contribution to the basic understanding of the phenomena which occur during life-time of a 'paint' film. It represents the resutls of a co-ordinated programme of research conducted over a decade by a team of experts in the field and organised by the Federation of Paint and Varnish Production Clubs, a technical organisation of the Paint and Varnish Industry in the United States of America.

How this research programme was visualised, various projects chalked out, results were correlated and evaluated are described in Chapter I. Chapters II and III describe the preparation of various compounds like driers, paint vehicles, esters and their pigmentation, under standard conditions and procedures so that uniformity and comparability of results could be achieved. The gain in weight of the test films, analysis of the films and their solvent resistance are dealt with in detail in Chapter IV supported by a number of tables of results. Data obtained by infrared and ultraviolet spectroscopy of the various paint films are brought out well in Chapter V to augment the results obtained by chemical analysis. Out-door exposure tests and accelerated weathering in a Weather-Ometer accompanied by hardness and abrasion tests are described in the two subsequent chapters. Correlation of results of out-door tests with those of Weather-Ometer is difficult and a rough estimation has been made after making a few allowances. Alkyds are reported to be markedly superior to the esters in the series of samples prepared. The next two chapters are devoted to yellowing, diminishing of gloss, porosity, permeability, water and alkali resistance of organic coatings mentioned in the project programme. Chapter X describes the oxygen penetration and shrinkage of films while Chapter XIII deals with oxidation studies. The protection afforded by a paint film depends on its adhesion and ability to withstand the strains developed during the various seasons. Stress and strain properties of paint film are given in Chapter XI. In the next chapter molecular size, shape and weight of paint film are evaluated. In the last but one chapter a survey of the entire project is made by statistical analysis of data obtained in various projects. All the results obtained from various projects are summed up in the last chapter and appropriate conclusions are drawn from the results of data. The present studies have demonstrated that no formulation is possible that will be ideal with respect to all desired properties of a paint film.

The book has been well compiled with care and at the end of each chapter references have been cited. The editor has dealt with the large amount of experimental data in an effective fashion and this book will be of interest to all those who wish to understand about the complexity of paint formulation and will provide a stimulus to further research in this field.

S. KRISHNAMURTHY.

The Chemistry of Natural Products, Vol. I. (*The Alkaloids.*) By K. W. Bentley. (Interscience Publishers, Inc.), 1957. Pp. vii + 237. Price $ 4.00.

This is the first volume of a series planned by Interscience Publishers Inc., on the chemistry of natural products. Only recently, a five-volume treatise has appeared on the chemistry of alkaloids under the editorship of Dr. R. H. F. Manske. The task of presenting the same subject in a brief volume of less than 250 pages is

bound to offer difficulties in the matter of choice and emphasis of topics. Dr. Bentley has discussed the elucidation of structure of representative members from various groups of alkaloids. Only the minimum information required to arrive at a particular structure is presented. In many cases if the same material is presented as an examination answer by students, it will be considered inadequate. Students will find it difficult to comprehend the chapter on biogenetic relationships, in which the treatment is mainly through formulæ. There is a danger of the student ascribing reality to the numerous compounds postulated as intermediates in biogenetic pathway, unless the speculative nature of these schemes is emphasised. The author could have cut down his treatment of the morphine alkaloids and included material on the Rauwolfia and Amaryllidaceæ alkaloids on which a great deal of work has been done in recent years. It is unfortunate that although the formulæ are clearly drawn, there are a number of errors. The book will certainly prove useful to students preparing for examinations. The good format and the reasonable price are features in favour of the book. T. R. G.

Semimicro Qualitative Organic Analysis. (*The Systematic Identification of Organic Compounds.*) (Second Edition.) By Nicholas D. Cheronis and John B. Entrikin. (Interscience Publishers, Inc.), 1957. Pp. 774. Price $ 9.00.

The volume under review runs to 774 pages and is undoubtedly the most comprehensive book available on qualitative organic analysis. Part I, occupying 158 pages, is concerned with a clear description of the equipment and techniques used in organic analysis. The authors are not content with describing only the simpler apparatus required at the undergraduate level but deal exhaustively with semi-micro apparatus of various types which will be found to be of great value to the research worker. The inclusion of adsorption, partition and ion-exchange chromatography among purification procedures is an excellent feature. Techniques of determination of physical constants like melting and boiling points, refractive index and optical rotation are fully described and the application of these data in the characterisation of organic compounds discussed.

Part II, occupying 160 pages, is concerned with procedures for the tentative identification of organic compounds. One of the most valuable features of this Part is the section on general tests for functional groups. Many novel reagents are introduced, which are rarely described in other books on qualitative organic analysis. An unusual feature is the inclusion of the use of infrared spectroscopy in the detection of functional groups. This must have been done in order to impress upon the student the advances made recently in techniques, rather than with the purpose of training the student in infared spectroscopy. It is doubtful whether even in the prosperous United States, undergraduates will be given access to these costly instruments for routine use in qualitative analysis. The treatment is too brief to be of use to the research worker.

Part III, occupying 212 pages, is concerned solely with the methods for the preparation of derivatives of organic compounds. Few other books deal at such great length or incorporate such useful details on the preparation of a variety of derivatives. This Part of the book will be of invaluable help to the research worker who is often faced with the problem of obtaining crystalline derivatives of compounds encountered in the course of research for purposes of analysis and characterisation.

In Part IV, the physical constants of a large number of organic compounds with different types of functional groups and of suitable derivatives of these are presented. This section will be extremely useful to the student in identifying the organic compound on which he has carried out a systematic analysis.

The massive size of the book and its high price will make it unsuitable for use by undergraduates in India studying chemistry, since the time devoted to organic qualitative analysis is very brief. Teachers in charge of instruction in organic analysis, post-graduate students and research workers will find the book invaluable. The book deserves to be known and used more widely than at present in institutions in India teaching organic chemistry. T. R. G.

Disinfectants—Their Values and Uses. By W. E. Finch. (Chapman & Hall, Ltd., London), 1958. Pp. 188. Price 30 *sh.*

There are quite a number of books on antiseptics which are valuable for reference and study. The book under review is somewhat different because it is not just a compilation of known work on the subject but it is the fruit of the rich experience of the author who has spent most of his working life in trying out details of assessing the value of various disinfectants and has himself had to work out formulations which are most efficacious.

The author has made critical analysis of

existing tests for evaluating antiseptics and stresses the importance of environment in the technical procedures.

The book contains nine chapters with a glossary of words and phrases and has both an author's index and subject index. Adequate references are given at the end of each chapter.

A chapter is devoted to formulation methods and the principles involved. Few books contain such detailed account of this subject which appear to be very important in producing active and stable disinfectants. The mysteries of the black and white fluids and the lysol types are explained as no other book does.

The chapter on surface sterilisation of fabrics like blankets and that of the skin is very enlightening as these do not just pass on information gleaned from other sources but also contain details of experiments which are of special interest.

The chapter on Hypochlorites is very welcome as there is an inclination to discredit these cheap and older disinfectants.

The chapters on Q.A.C. and substituted phenols are well worth reading. In these days of indiscriminate use of antibiotics and other chemotherapeutic agents, it is refreshing to know that the older antiseptics have still their own place.

This is a timely publication and, as Professor H. Berry points out in his Foreword, the book is certain to be welcomed by research workers, manufacturers and all those users of disinfectants who take an intelligent and responsible interest in these important products.

J. C. D.

The Leukemias. (*Etiology, Pathophysiology and Treatment.*) Edited by J. W. Rebuck, F. H. Bethell and R. W. Monto. (Academic Press, New York), 1957. Pp. vii + 711. Price $ 13.00.

The book records the proceedings of an International Symposium on the Leukemias, organised by the Henry Ford Hospital, Detroit, from March 8-10, 1956. It has been stated in its Preface that it "is in a very real sense the result of co-operative effort". Almost every facet of the subject such as the structure and antigenicity of the leukemic cell, the genetic and environmental factors in the transmission of the disease, radiation biology of leukocytes, the physiology of leukocytes and the various chemical, diagnostic and nosological problems concerning the disease, as well as its modern therapy, have been discussed by leading research workers in these different fields with admirable clarity.

The advances made in the knowledge of the group of diseases (Leukemias) during the last 30 years have been far-reaching but complex. Consequently, to get a fair appraisal of these advances it was necessary, not only to study the problems of the finer structure of cells with electron microscopy, but also with the aid of "immunological, biochemical, metabolic, microbiologic, endocrine, genetic, toxicologic and isotopic routes".

In the latter half of the volume, an attempt has been made to present as complete a biochemical picture as possible. Part VI, for example, deals with fundamental studies on amino acid and nucleic acid metabolism in leukemic patients. The excretion of β-amino isobutyric acid and studies with cystein metabolism in leukemic patients reported by Awapara and Weisburger respectively are noteworthy. Particularly interesting are the results obtained with selenium cystein as an anti-leukemic substance. The paper by Krakoff on the excretion of uric acid in human patients treated with various anti-leukemic drugs needs special mention. On the basis of serum uric acid determinations 2 to 3 times a week and daily uric acid excretion in patients, certain tentative hypotheses have been advanced "about the mechanism of the uric acid abnormality in leukemia and the relationship of this mechanism to the therapeutic measures which have been found to have some favourable effect upon the disease". This is all the more important because it deals with human leukemic patients and thus it is free from errors of extrapolation of data from experimental animals to humans. The presentations of Buchanan *et al.* on "specific action of azaserine" and that of Goldthwait on "Purine nucleotide biosynthesis and neoplasia" are excellent and may be quoted as models for the study of the mechanism of action of drugs at enzymic levels. An *in vitro* method of screening anti-leukemic drugs reported by Winzler may provide a useful tool, particularly since the number of anti-leukemic drugs is rapidly increasing.

One of the main obstacles to effective cancer chemotherapy is the occurrence of drug resistance, about which very little is known at present. In this context the papers by Nichols on "Resistance to Folic Acid Antagonists" and that by Hutchison on "Drug Resistant *S. fæcalis*" are stimulating and welcome contributions. However, the best part of the volume comprises the proceedings of the round table discussion on treatment. In this Wintrobe has discussed the

criteria for evaluation of therapeutic responses. Farber, a pioneer in the field of chemotherapy of leukemia, has reviewed his experience with antifolics and Burchenal has reviewed the results of combination therapy of 6 mercaptopurine and azaserine. Hill and Gellhorn have presented their data on chemotherapeutic trials with corticoids and Damashek has reviewed his experiences with newer agents like TEM and Myleran. Clinical trials with newer antimitotic substances analogous to colchicine are reviewed by Moeschlin.

This book will prove very useful not only to clinicians but also to persons who are interested in leukemia whether in the clinic or in the laboratory and could be recommended as a baseline study for all further work on this subject.

V. R. K.

The Species Problem. Edited by Ernst Mayr. (American Association for the Advancement of Science), 1957. Pp. v + 1-395. Price $ 8.75.

It is at once extremely interesting and challenging that in spite of two centuries of analysis, the "Species" remains a problem. It could almost be said that of all problems in biology here is one that has continually defied solution. Several attempts have been made in the past to find a solution, but every time the "Species Problem" has raised its head with greater vigour and persistence, with the result that in the middle of the 20th century, we are still debating it.

There is however one definite improvement in position. We seem to understand the problem better today than we ever did before. We also understand the difficulties that are in the way of its solution, more clearly. And that is one definite forward step. We realize also that hasty and dogmatic assertions are not likely to contribute to its solution. That is another forward step too.

That is because the almost limitless diversity of plant and animal life may not permit the application of one single standard yardstick to measure the species concept. What are the criteria that one has to employ for the determination of a species? Are these criteria of universal application to all animals and plants? If they are not, is there not something wrong with the concept of species itself, as we now understand it? Shall we modify it in some way so we can make it applicable to all organisms? These are some of the questions raised (but not necessarily answered) at the symposium of the A.A.A.S. in 1955. Perhaps for the first time, students of varied disciplines in biology have come together to discuss it. For, 30 years ago, who would have thought that physiologists, embryologists and geneticists would sit together to discuss the problem which was regarded as the exclusive preserve of the systematist, with occasional permission for a morphologist to enter briefly?

For it is now recognized that the species problem is a universal problem impinging on every aspect of biological thought. You may define it as you like, you may push it afar or draw it near but its presence is ubiquitous and pervasive.

Nine papers were presented at the Symposium, Ernst Mayr contributing two. Mayr was eminently fitted for the task of co-ordinating the discussions as its Chairman. His analysis of speciation among birds is among the lasting contributions to biological thought of this century. He was therefore able to present not only different concepts and definitions of species as he does in his first essay, but also the difficulties that beset the student of species, in his last contribution. Carson, from the geneticist's view-point, looks upon species as a system of recombining genes,—a gene pool,—from which continually, smaller units of recombination, with varying degrees of isolation, are given off, resulting in different levels of integration.

Verne Grant's analysis is from the viewpoint of a field botanist. He recognizes a continuous and gradual process of evolution from individual to population, from population to race and race to species. The extensive occurrence of asexual means of propagation among plants often nullifies this process but is more than made up by other advantages like hybridization, which occurs far more freely among plants than among animals, and which is probably the largest single factor responsible for plant speciation. The two striking examples chosen by Brooks for his analysis of speciation in fresh-water animals,—the crustacean *Daphnia* and the whitefish *Coregonus*,—illustrate the amazing variations that emerge from the same genotype and reflect "the ability of the genotype to prosecute successful development over the wide range of environmental conditions occurring in the fresh-waters that these animals inhabit". An added difficulty is the occurrence of several variable species of both genera in the same environment resulting in extensive hybrid formation and introgression. The species problem in these two organisms and possibly in other fresh-water animals is therefore

of a quite different nature. When we come to fossil species, however, we notice there is much controversy and even confusion. Incompleteness of fossil records, and an almost entire reliance on morphological traits of limited category, contributes to this difficulty and it is at once recognized that the palæontologist works in a rather circumscribed area. Sonneborn's "masterly synthesis" deals with problems of speciation in the Protozoa, particularly among ciliates, whose peculiar population structure is perhaps responsible for many aspects of their reproductive patterns. He has dealt with the whole problem of variation in these organisms, the inadequacy of morphological and physiological criteria for determining species. With the newer knowledge about serology, host-parasite relationships and reproductive phenomena, it can now be seen how delicate the species is balanced in the Protozoa. Moore relates the astonishing variations in embryological adaptions in closely related organisms often regarded as species but with geographical isolation, and makes a plea for an adequate recognition of environmental factors on development in any delineation of species. Prosser brings in evidence of many physiological characters, especially stress tests, that can provide evidence of variation in natural populations. This is as yet a new discipline and further information about physiological variation is necessary; but analysis of cellular and enzymatic processes and their variations in different organisms would undoubtedly throw a great deal of light on the problem of species at this level.

As Mayr says, "it would be too much to expect the Symposium to solve the species problem", but there is no doubt it has made a solid contribution to its understanding.

B. R. SESHACHAR.

General Microbiology. By R. Y. Stanier, M. Doudoroff and E. A. Adelberg. (Macmillan & Co., Ltd., London), 1958. Pp. xxii + 682. Price 50 *sh.*

Last two decades have witnessed rapid advances in our knowledge of biology of micro-organisms and in regard to the elucidation of their chemical activities that it has become impossible for any individual to canvass completely and digest adequately all the information available even in one specialised field of microbiology. The task becomes all the more difficult to a beginner in the subject as he is unable to interpret properly the reviews, research publications and monographs intended for readers at an advanced level with the result he is left with materials difficult to digest. This book, written by three experienced professors in the subject, is an answer to his quest for a well-organised text-book in *General Microbiology*. What is more, the book covers almost the entire field of the subject and provides not only the necessary "Biological Background" for a better "comprehension of the elements of microbiology" but conveys succinctly a modern synthesis of microbiological knowledge in a fascinating way to make the text one of absorbing interest.

The book is appropriately divided into three parts, the first two parts corresponding roughly with two major phases of microbiology, *viz.*, "The Properties of Micro-organisms", and "The Ecology of Micro-organisms". The third part is devoted rightly to a review of the principles of cellular biology which would enable the student not only to have a better grasp of the material presented in the other two parts but also for a proper appreciation of biological sciences dealing on such important topics as matter and origin of life, energy and life, natural selection, genetics, taxonomic categories, classification, etc., all of which have been summarised in an admirable way for the reader. Another feature of this book is that its running text material is not disturbed with references and the new student has not to, in consequence, encounter any formidable bibliographies at the end of every chapter. A judicial selection of a score of books with critical appreciation thereof is however given for those interested in covering wider aspects of the field.

Part I consists of 19 chapters, and Part II consists of next 11 chapters and all these together cover adequately the major groups of micro-organisms, their ecology and interrelationships. Important topics as "Principles of Chemotherapy", "The Dynamics of Disease in Populations", and "The Exploitation of Micro-organisms by Man" have been dealt with separately. Every chapter is preceded with a table of contents pertaining to that chapter and this should prove of immense help to a beginner to locate easily any text material.

The type used is large and clear and is arranged in a fashion which is inviting and conducive to reading. Names of micro-organisms and all new and/or technical words are italicised. The style of writing is simple, clear and expressive. The volume is profusely illustrated with excellent graphs, photographs, photomicrographs, electron micrographs and diagrams which help fully explain the principles and practice of microbiology. In short, the book

serves the purpose intended, is moderately priced, and should find wide acceptance as a teaching tool for the teachers and a valuable text-book for the students of microbiology and as such is warmly recommended. J. V. B.

Lectures in Immunochemistry. By Michael Heidelberger. (Academic Press, New York), 1956. Pp. ix + 150. Price $ 4.00.

This volume consists of nine lectures delivered by the author during the last ten years, six of which were given at the University of Tokyo, Japan, in 1955.

The first lecture, Immunochemistry—Past, Present and Future—deals with the historic development of immunochemistry under the impact of the introduction of quantitative micromethods on the chemistry of antigens and antibodies. The second lecture discusses the nature of the antigens and the antibodies and the theories of antibody formation. The development of quantitative analytical methods, utilising the nitrogen-free antigen and partly purified antibody as applicable to precipitin reactions and the kinetics of these reactions are lucidly presented in the third lecture. Bacterial agglutination and the consequences of quantitative studies on the precipitin and agglutinin reactions; relations between constitution and immunological specificity and complement and immune hemolysis are the titles of the other three lectures in this series.

These six lectures present to the readers a comprehensive account of Immunochemistry, a branch of science still in a highly speculative and experimental stage.

The close relation between the theoretical and the practical, as exemplified by the application of the fundamental principles of the science of immunity to public health, and persistence of antibodies in man after immunization and some facets of precipitin reaction form the concluding chapters of this instructive booklet.

M. Sirsi.

An Atlas of Air-borne Pollen Grains. By H. A. Hyde and K. F. Adams. (Macmillan & Co., Ltd., London), 1958. Pp. xvi + 110. Price 36 *sh.*

Palynology is one of the modern integrative sciences that has its ramification in such diverse fields as taxonomy, climatology, archæology, medicine, phytopathology, etc. Some very valuable publications on the subject have appeared during recent years but regional surveys, especially illustrated ones like the *Atlas* in question, will always be most welcome.

This *Atlas* is an excellent little book based on investigations that extended over a period of 15 years and that were intended primarily "to form the bakground to the study of inhalant allergy", the authors being associated with Asthma and Allergy Research Unit of St. David's Hospital, Cardiff. It comprises 112 pages of fine art paper carrying about 190, unnumbered black and white microphotographs of pollen belonging to 92 species caught from the air in Great Britain at 15 different collecting stations. Most of these species were identified by the authors from the vegetation growing in the neighbourhood of collecting stations. While majority of the species identified are obviously anemophilous, some 30 of them are such as are usually regarded entomophilous.

After a brief half-a-page Preface, there follows a three-page Introduction in which the authors state their objective and give some details on: technical methods; the morphology of the pollen grain; measurement; and contents and arrangement. This is followed by a dichotomous "key to air-borne pollen grains". As a result of a "master key", six types of grains are recognised—compound, vesiculate, inaperturate, porate, colpate and colporate. These are further sorted out into genera. This is perhaps the most useful part of the text.

The main part of the book is a "descriptive catalogue of air-borne pollen grains", that is, in two parts. Part I is devoted to angiosperms, and Part II to gymnosperms represented only by the Coniferæ. In Part I, the arrangement is alphabetical by families and genera respectively, while in Part II, it is alphabetical by genera.

The plan of treatment of material is the same in all cases. For pollen of every species there is a brief enumeration of salient features concerning exine, furrows, polar fields, pores, intine, etc., and two (occasionally one or more) microphotographs, one showing one or more pollen grains in optical section and the other the same in surface view. All the photographs have been taken at a magnification of 800 diameter. Most of them are exceptionally clear and collate well with the description.

At the end there is a brief glossary of "morphological terms" and "conventional terms" followed by a select bibliography of a dozen references and a brief index.

The reviewer is somewhat disappointed at the scant attention paid to the text. The title of the book demands that some information should have been given about the methods used in trapping air-borne pollen, the changes that the

pollen undergo during their flight, and the difficulties encountered in handling them in laboratory. As it is, the title of the book appears to be somewhat inappropriate as here the emphasis is on air-borne pollen while in the text and illustrations the emphasis is on fresh pollen, of course obtained mostly from anemophilous plants.

Despite these shortcomings the *Atlas* is a valuable addition to the current growing literature on palynology. Both the authors and the publishers deserve our congratulations for the excellent photographs and perfect reproduction.

V. PURI.

Books Received

Solid State Physics. (Advances in Research and Applications), Vol. IV. Edited by Frederic Seitz and David Turnbull. (Academic Press, Inc.; India: Asia Publishing House, Bombay-1), 1957. Pp. xiv + 540. Price $ 12.00.

Rockets, Missiles and Space Travel. By Willy Ley. (Chapman & Hall, London W. C. 2; Asia Publishing House, Bombay-1), 1957, Pp. xv + 528. Price 50 *sh.*

Electronic Measuring Instruments. Second Edition. By E. H. W. Banner. (Chapman & Hall, London W. C. 2; Asia Publishing House, Bombay-1), 1958. Pp. xvi + 496. Price 56 *sh.*

Organic Electrode Processes. By Milton J. Allen. (Chapman & Hall, London W. C. 2; Asia Publishing House, Bombay-1), 1958. Pp xiv + 174. Price 32 *sh.*

Disinfectants, Their Values and Uses. By W. E. Finch. (Chapman & Hall, London W. C. 2; Asia Publishing House, Bombay-1), 1958. Pp. 188. Price 30 *sh.*

Satellites and Spaceflight. By Eric Burgess. (Chapman & Hall, London W. C. 2; Asia Publishing House, Bombay-1), 1958. Pp. vii + 159. Price 21 *sh.*

SCIENCE NOTES AND NEWS

Two New Improvements in Electromagnetic Weighing

Mr. D. N. D. Kaikiny of the Craftsman Electronic Corporation (Private), Ltd., Bombay-10, writes as follows: An electrobalance for micro-analytical weighing is a necessary adjunct in any well-equipped research laboratory. Its application is especially useful with tests undertaken by means of a microscope, microtome, spectrograph, spectrophotometer, colorimeter, polarograph, etc., involving microgram weighing. The passing of a measured current through the coil of a d'Arsonval movement to counterbalance the load applied to the pointer, is the most common method.

However, the new improvement of operating the electrobalance on a 6 volts dry battery is distinct progress, because it eliminates (i) the Mains power fluctuations, and (ii) the use of special bulb which hinders operation by breakdown due to various causes. These special bulbs are hard to obtain in the market. The 6 volts dry battery method offers most simplified operation giving readings in a second or two. Secondly, the provision to remove the weighing compartment to a considerable distance enables operation in inaccessible places, such as hot radiation cells, dry boxes, etc.

These improvements will undoubtedly lessen the chores of the research worker.

Super-High Pressures—Age-old Dream Comes True

The physics of super-high pressures opens out a large vista of research providing good promise of unexpected results in various branches of science. For example, it has been determined that solid materials obtain new properties when placed in a liquid compressed to several tens of thousands of atmospheres.

The combination of high pressures and temperatures made it possible for the old dream of scientists to come true. It is known that diamond and graphite consist of the same atoms of carbon having only a different arrangement. Many attempts were made to change the crystal lattice of graphite and convert it into diamond. It became possible to develop an enormous pressure of 427 thousand atmospheres during one test but only at room temperature and the goal of obtaining diamond was not reached. It turned out that small artificial diamonds could be obtained at a temperature of nearly 3,000° and at a pressure of 100,000 atmospheres. The importance of this discovery is exceptionally great though the cost of such diamonds is higher than that of natural ones.

The combination of high pressures and temperatures made it possible for scientists to obtain also very hard crystals by combining boron with nitrogen thereby producing borazon. The

hardness of the latter exceeds that of diamond and it is so great that borazon leaves scratches even on diamond which is the hardest natural material. It should be noted that unlike diamond, borazon can be used with success at temperatures upto 2,500° C.—*Laboratory of Physics of Super-High Pressures, USSR Academy of Sciences.*

Satellite Anniversary

October 4, 1958 marks the anniversary of the launching of the first artificial earth satellite. The launching of the Sputnik I on October 4, 1957 marked the beginning of the conquest of cosmic space by man. The first satellite made 1,400 circuits round the earth, covering about 60 million kilometres in the course of 92 days. Sputnik II, which carried the dog Laika, existed for 161 days and covered more than 100 million kilometres making 2,370 circuits round the earth. Sputnik III, weighing 1,327 kg., and its carrier rocket are now circling our planet. It has already covered nearly 100 million kilometres. The initial period of about 106 minutes has declined by 2·1 minutes and is now 103·85 minutes. Accordingly, the apogee has decreased by 190 km. and it is now 1,690 km. The wireless transmitter, fed from a solar semi-conductor battery, has been reliably functioning for the past 4½ months. The automatic control of all scientific and measuring instruments is effected by devices based exclusively on semi-conductors of which several thousand elements had been installed in it. The information received with the help of the Sputniks throws new light on many aspects of the physics of the troposphere.

Transuranic Elements—Their Place in the Periodic Table

The ten new elements ranging from neptunium (Z = 93) to nobelium (Z = 102), constitute a new group analogous in electronic structure to the rare earth elements. This implies that the 5 *f*-electron shell is progressively filled. It would have its maximum complement of fourteen electrons in the hitherto undiscovered element of atomic number 103. This electron assignment is based, first, on the analysis of the emission spectra of some of the elements in question. Secondly, the magnetic properties are analogous to those of the rare earth elements. Thirdly, crystal structure determination of many solid compounds of the new elements have enabled values of ionic radii to be assigned. These show a decrease as the series is ascended, which parallel closely the well-known lanthanide contraction in the rare earth series. Absorption spectra of the transuranic elements also show characteristic sharp absorption bands, associated with transitions within the shielded 5 *f*-level.

Chemically, the new elements differ from the rare earths in that, instead of having predominantly a valency of three, higher values are found. This is associated with the great ease with which the electrons are lost.

The maximum valency of 6 is most stable in uranium, but it is also observed in neptunium, plutonium and americium. Curium and berkelium, the next two elements, have valencies of 4, but, so far as is known, the higher members of the series are restricted to a valency of 3. (Prof. H. J. Emeleus in his Presidential Address to Section B of the British Association Meeting in Glasgow, *Nature*, 182, p. 579.)

A New Stage in the Development of Astronomy

At a Meeting of the International Astronomical Congress in Moscow on August 14, Dr. Lallemand (France) reported that French scientists had succeeded in obtaining the spectra of remote galaxies which had hitherto been beyond the reach of ordinary astronomical instruments. They had used instruments of a new type—electron-optical converters—which greatly amplified the brightness of heavenly bodies.

The rays from remote galaxies fall on a highly sensitive cathode in the instrument and cause it to emit an electron beam. After passing through an elaborate system of amplifiers, the beam is reproduced on a luminiscent screen, on which a greatly amplified image of the galaxy appears. Electron-optical conversion is 50 to 100 times more sensitive than ordinary photography.

The new instrument has also proved effective in photographing the Sun and the use of the combined method has turned out to be far superior to ordinary photography, particularly in recording rapid changes in the Sun's corona. The time of the exposure can be reduced by this method to between one-fifth and one-tenth of what was previously required and there was no blurring in the photographs.

Important Discovery on Nucleons

The results of experiments with the proton synchrotron of the Joint Nuclear Research Institute in the town of Dubna, near Moscow, where a technique has been developed for obtaining purified beams of anti-protons, prove that there are two types of nucleonic collisions—peripheral and central. During peripheral collisions the nucleons retain their individuality, i.e., the

proton remains a proton and the neutron remains a neutron. It is possible that in the central collisions protons are transformed into neutrons and *vice versa*. In both types of collisions light particles—mesons—are formed; when the collisions are central their number increases many times over.

The important discovery leads to the conclusion that elementary nuclear particles have two regions—a periphery or a kind of envelope, and a core. This was announced by Academician Vladimir Wexler at the Atoms for Peace Conference in Geneva.

Potassium Chloride from Sea Bitterns

At the Central Salt Research Institute at Bhavnagar, a simple and economic process has been developed for the recovery of potassium chloride from sea bitterns, which are now largely allowed to go waste. Bittern is the name given to the oily liquid which remains after the extraction of salt from sea-water.

India's annual production of sea salt is about 3 million tons. The bitterns let to waste after the recovery of sodium chloride have been found to contain appreciable quantities of potassium chloride and it is estimated that as much as 80 to 85 thousand tons of potassium chloride could be recovered from them.

The bitterns are concentrated to the required degree by solar evaporation and treated with lime slurry to precipitate the magnesium sulphate. The supernatant liquor containing mostly potassium chloride and chlorides of sodium and calcium is further concentrated until most of the sodium chloride and potassium chloride crystallise out. From the product, so obtained, potassium chloride is separated by further crystallisation.

Kit for Detection of Ghee Adulteration

The Central Food Technological Research Institute, Mysore, has devised a cheap and simple Ghee Testing Kit which makes detection of ghee adulteration easy.

The kit consists of a marked test-tube, a sealed capsule containing a little acid, a sealed capillary containing some other chemicals, and a cutter. The testing itself is a simple process and can be easily understood and mastered. The main attraction of the kit, however, consists in its inexpensiveness. The entire kit (including chemicals) costs about 8 nP., and the recurring cost of each test does not exceed 3 nP.

Fourth Congress on Theoretical and Applied Mechanics

The above Congress will be held at the Bengal Engineering College, Howrah (Calcutta), from December 28-31, 1958, under the Presidentship of Dr. S. R. Sen Gupta.

Research papers to the Congress will cover the following subjects:

1. Elasticity-plasticity-rheology; 2. Fluid mechanics (Aerodynamics-hydrodynamics); 3. Mechanics of solids (Ballistics-vibrations-friction-lubrication); 4. Statistical mechanics—thermodynamics—heat transfer; 5. Mathematics of physics and mechanics-methods of computation; (6) Experimental techniques.

Further information regarding the Congress can be had from the Secretary-Treasurer (Dr. B. R. Seth), Indian Institute of Technology, Kharagpur.

IX International Botanical Congress

The Ninth International Botanical Congress is to be held in Montreal, Canada, in August 19-29, 1959.

Dr. T. S. Sadasivan of the University of Madras has been invited to act as a Vice-Chairman of the Phytopathology Section. Dr. T. V. Desikachary has been invited to organize a symposium on "Electron Microscopy and Algal Structures".

Birbal Sahni Institute of Palaeobotany, Lucknow

The Eleventh Annual Scientific Meeting of the Palæobotanical Society will be held at the Institute's premises on the 17th and the 18th of January 1959. The programme chalked out includes lectures, reading of papers and discussions. Palæobotanists from all over India are expected to participate.

Award of Research Degree

Poona University has awarded the Ph.D. Degree in Chemistry to Shri Vasant Ranganath Keskar for his thesis "Studies in Thermal Polymerization of Dehydrated Castor Oil".

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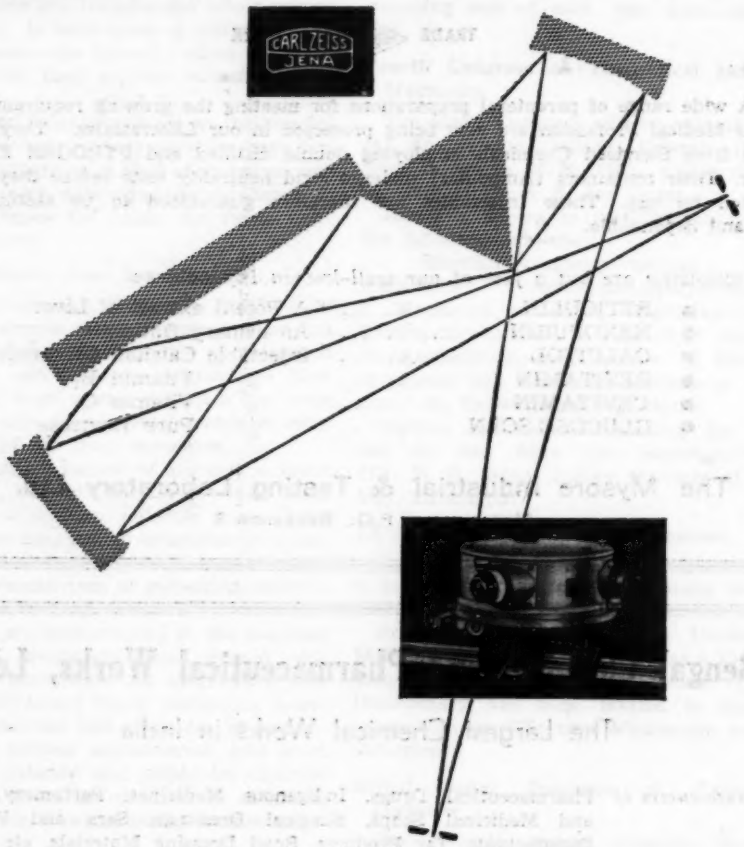

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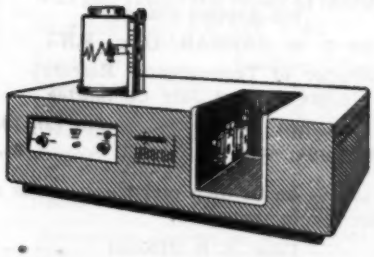

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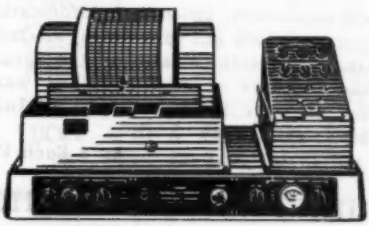

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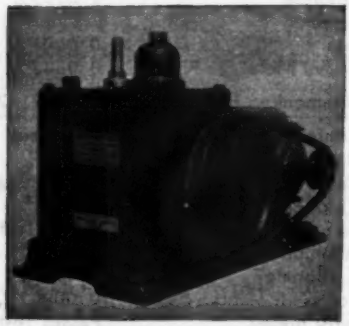

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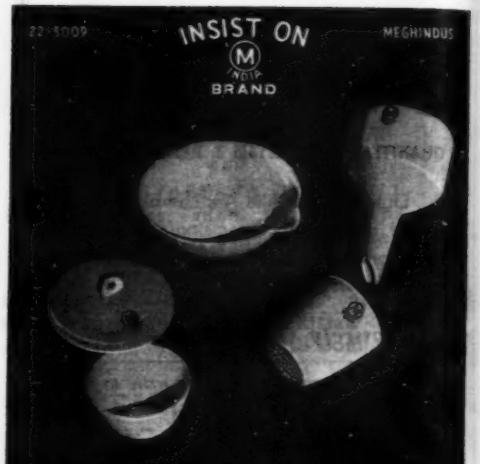

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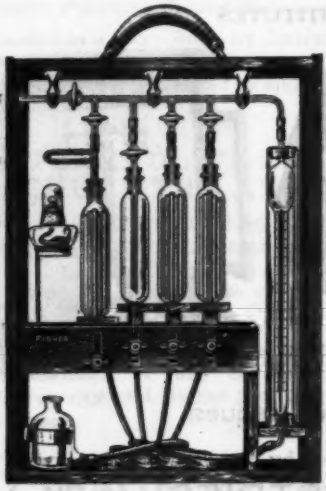

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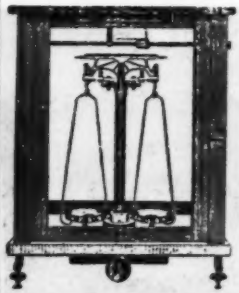

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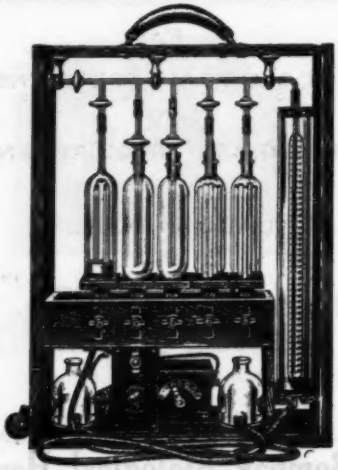

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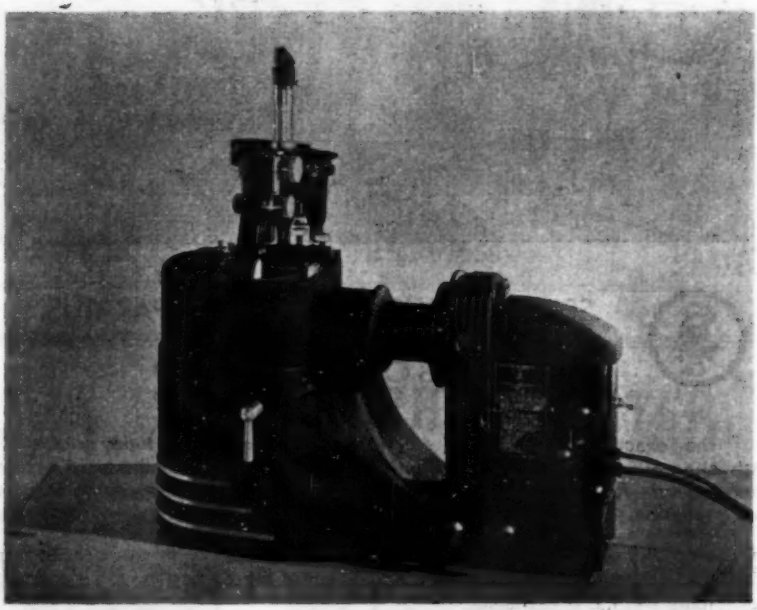

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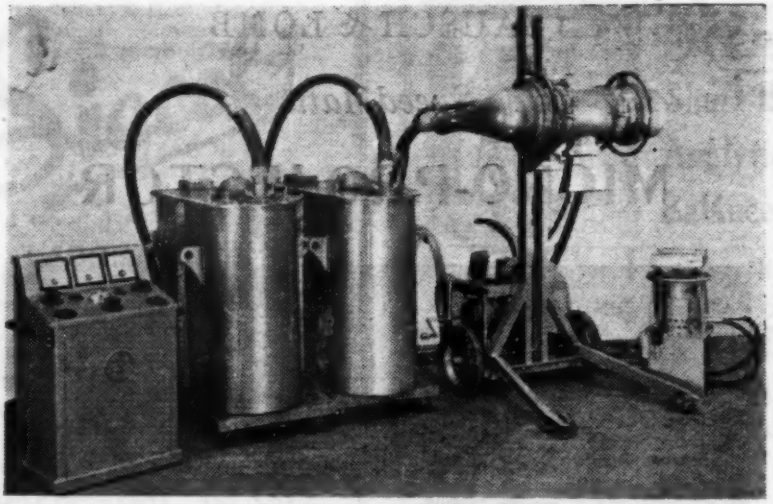

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